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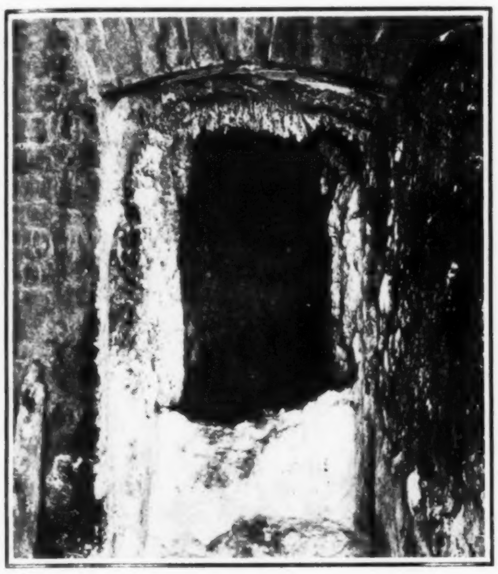
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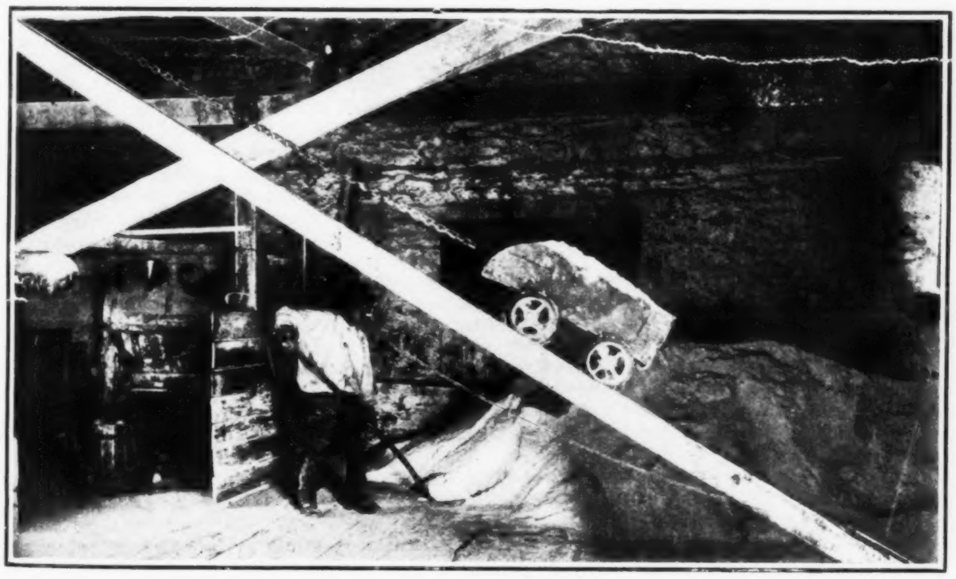
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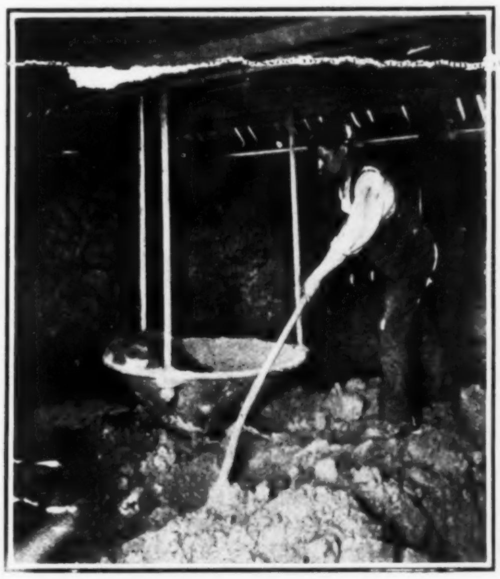
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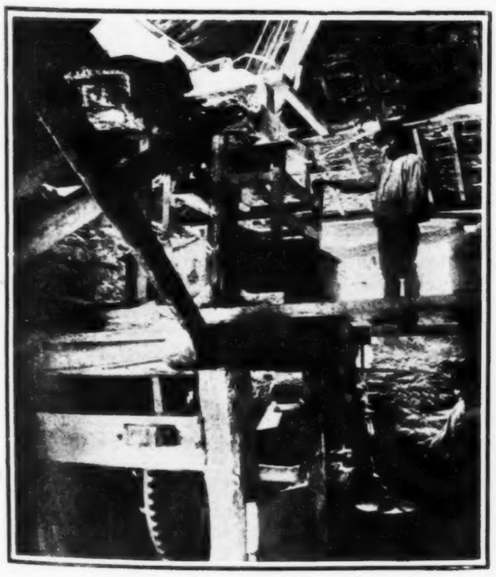
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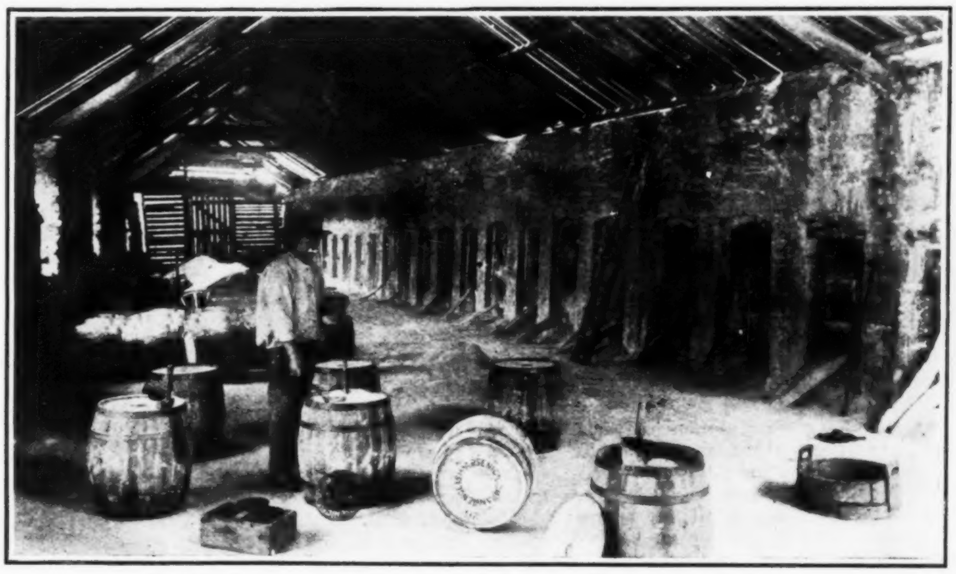

PACKING ARSENIC; A ROW OF FLUE CHAMBERS ON THE RIGHT.

THE ARSENIC INDUSTRY OF CORNWALL.

THE ARSENIC INDUSTRY OF CORNWALL.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Though the English county of Cornwall is primarily dependent for its prosperity upon the mining of tin, yet within the past few decades it has attained a pre-eminent position in the supply of arsenic, an important commercial product, which is associated with, and relies for its success upon, the premier industry. There is an increasing demand every year for this substance beyond the requirements of the chemist, for it now enters into the manufacture of a wide variety of articles in daily use, such as various pest-removing compounds used by the agriculturist and farmer, aniline dyes, lead for shot, certain descriptions of glass, and so forth.

At the present time the total number of manufactories in all parts of the world devoted to the production of arsenic aggregates less than forty, of which a large proportion are located in Cornwall and the adjacent counties in South Wales, the former, however, constituting the largest center of production, its output for 1906 totaling 1,599 tons. The demand for white arsenic is greater than the supply, one manufacturer of sheep-dip in the United Kingdom alone consuming some 1,000 tons per annum.

The creation of this industry, so far as Cornwall is concerned, was due to the depredations, in the United States, of the Colorado beetle. As the result of numerous experiments and researches that were carried out by various scientists in all parts of the world—for the plague subsequently spread to Europe—it was found that arsenic constituted the only infallible eradicator. Immediately a heavy demand for the mineral ensued; and owing to the vast quantities of raw material discarded in the production of tin in Cornwall, with which the arsenic is found associated, several factories sprang into existence, which in a short time had a combined output of 1,000 tons per month, the price meanwhile having increased from six to thirty dollars per ton, this country proving the greatest customer while the fight with the Colorado beetle was in progress. Since that time the output has diminished, a result, however, partially due to the decreasing supplies of the white mundic, from which the arsenic is obtained. The decrease in supply, however, has raised the price, until now it averages about $160 per ton.

Previous to this development the presence of the white mundic, as the arsenical pyrites is popularly termed, was regarded as a nuisance by the tin miners. The only benefit that accrued to them from its existence was that it demonstrated where tin prospecting might advantageously be carried on, since the latter metal is generally found either associated with this mineral, or some distance below it. When the tin could only be found with the arsenical pyrites the miners rather bemoaned their luck, as the combination necessitated calcining of the ore in order to remove the arsenic, the presence of which with the tin rendered the latter very brittle and harsh. Consequently, all over the county may be seen mounds representing the accumulation of centuries of discarded refuse from the tin mines, with which the mundic is combined in more or less large quantities. In many instances the pyrites were cast on one side, and ultimately used as metal for roads, for which it was found to be excellent.

But with the demand for arsenic for stamping out the Colorado beetle, the whole aspect of affairs was changed. Calcining ovens designed purposely for roasting the mundic or mispickel were laid down, and the refuse mounds became jealously guarded. Large numbers of men, women, and children were pressed into service to pick over the heaps in search for the arsenical pyrites, while even the roads that had been metaled therewith were torn up. The demand for arsenic came at an opportune moment for the county, since the price of tin had sunk to such a low level that many of the mines had shut down owing to their small yield of pure ore, the cost of calcining for the removal of the mundic rendering them unremunerative. These mines were once more opened up, principally not for the tin, but the pyrites, while those mines which were still working in the anticipation of tin rising in value were placed upon a firmer footing, since they were able to exploit for two or more profitable minerals—copper or tin and arsenic.

The manufacture of arsenic is a simple process. The ores are roasted in the ovens, and the arsenic is driven off in the form of a white soot, in just the same manner as the volatile carbons are emitted from burning coal, and collect upon the sides of the shaft. In the earlier days the calciners were forced to reduce the emitting of arsenic soot from their chimney shafts, in accordance with the stringent regulations of the government, which stipulated that only a certain maximum quantity of the arsenical soot should be permitted to escape into the atmosphere, under pain of heavy penalties. Under these circumstances the process was a troublesome one, the chimney shafts being so built as to prevent the escape of the arsenic, which clung to the sides of the shaft, from which it was periodically removed and discarded.

For the volatilization of the mundic, shafts have now been specially constructed, the volatile agents having a long passage to traverse before the outer air is gained. In some instances these shafts, or rather series of chambers, extend for a length of over 1,000 feet, being arranged so as to offer the maximum resistance to the passage of the flying arsenic crystals. The chambers of the kiln are pierced at frequent intervals with small arched orifices, giving entrance to the chamber within, which measures from 3 to 4 feet in width by 5 feet or 5 feet 6 inches in height. This orifice is provided with an iron door, which seals the opening during the calcining operation. Curiously enough, although the arsenic quickly volatilizes, it as quickly condenses directly it is removed from the neighborhood of the fire. Consequently, the deposits are thicker at those chambers of the shaft nearest to the fire, and similarly the yield is least at those chambers nearer the outer opening of the shaft. In the calcining process the sulphur is first volatilized and escapes in the familiar yellow fumes, giving way to fumes of a grayish white which represent the arsenic.

Roasting is carried out for the most part in what are known as Brunton calciners. This kiln comprises a large dished pan some 15 feet in diameter, which is revolved before the fires, so that every part of the contents may be subjected to the maximum influence of the heat. The pans or beds make from five to ten revolutions per hour, and in the roof of the furnace are carried cast-iron plates called "flukes," which are disposed at an angle of 45 deg. so as to plow the contents of the calciners during rotation toward the periphery of the pan, this action continually turning over the mineral mispickel, so as to secure complete treatment. The arsenical pyrites are first crushed to a coarse powder, while the tin ore impregnated with arsenic is first passed through the stamps, which reduces it to the consistency of sand, and then shoveled into the calciner for roasting. At some of the more recent mines and arsenic works the Brunton kiln has been superseded by a flat-bottomed calciner, but the result is the same. The kilns are capable of dealing with from four to five tons of pyrites every twenty-four hours, the coal consumption averaging about 220 pounds per ton treated.

When the kiln is charged, all openings to the chambers are carefully sealed, the edges of the iron door being plastered over, since owing to the striking affinity of the arsenic for oxygen, the slightest crevice will constitute a great source of leakage. While the kiln is in operation, the escape of the arsenic fumes can be detected here and there in the form of little jets, which the workmen describe as "smeeching." So volatile is the soot, that it will penetrate the slightest nook and cranny that may exist in the shaft or chambers, and occasionally, when the flues are overhauled, vast deposits of the soot will be found in the various crevices in the masonry or beneath the floor of the chambers.

The chambers are opened at irregular intervals, this operation being governed by the amount of mundic that has been charged into the calciner. Those chambers nearest to the fire become the heaviest charged, the soot clinging to the walls to a thickness of several inches, while at the extreme end of the shaft, where it communicates with the outer air, scarcely any traces of the soot will be found. The deposits are removed by means of shovels, and resemble dirty castor sugar in color, owing to the soot being contaminated with the volatile carbons from the coal and other substances. This is the raw arsenic, containing about 70 per cent of the mineral and some 30 per cent of impurities. For commercial purposes the crude material has to be submitted to a second refining operation, which exactly resembles the first, except that anthracite coal and coke are employed for the stoking instead of the ordinary bituminous and coarser grades of coal utilized in the first calcining.

For the refining process, moreover, the shaft is considerably shortened, being practically a flue about 100 feet in length, terminating in a series of chambers similar to those in the first operation, numbering up to twelve. The heat here generated is somewhat more intense, so that the arsenic fumes travel a proportionately greater distance before condensing and depositing upon the sides of the "kitchens," as the compartments are called. The coarse volatile products of combustion which became combined with the arsenic in the first stage, collect upon the walls of the 100-foot flue, while in the kitchens only practically pure arsenious anhydride is procured.

The sight produced when the chambers are opened is strikingly interesting. In the first two chambers, i.e., those nearest the furnace, the deposit is not very thick, but in the subsequent kitchens, 3 to 10, the yield is very heavy. The walls and floor are covered to a depth of from 20 to 30 inches with entwined glittering masses of arsenious anhydride in the form of crystals of brilliant whiteness. The product is gathered and transported to the milling room, where it is milled like wheat flour into the fine powder which is so familiar, and packed into tubs for export.

The process of manufacture is perfectly innocuous to the employees, provided reasonable precautions are observed. Respiratory masks are worn in the stages beyond calcining, to prevent the incursion of the fine dust into the lungs. The most common malady if the rules of cleanliness are not followed is a painful skin eruption called familiarly "pickling." Above all things, it is essential that the operatives should keep cool, since perspiration by opening the pores of the skin affords and facilitates an entrance for the dust to the system; neither must hot-water baths be indulged in for the same reason.

The foregoing applies to the manufacturing process as carried out in Cornwall, and which is the most generally adopted; but in the Widnes and Runcorn district, which is the alkali country of England, a new patented process of manufacture is coming into vogue. In this instance the arsenious anhydride is recovered in a very pure form from arsenical vitriol, produced from highly arsenical pyrites. This method is but in its infancy, but there are now five factories following the system; and owing to numerous improvements that have been incorporated, it promises to come into more extensive application in the immediate future. It is essential, however, that the plant for carrying out the preparation by this means should be very carefully designed and operated, since in the process the arsenic is volatilized from the acid as arsenious chloride; and owing to the poisonous properties of the substances dealt with, special precautions must be taken for the protection of the employees.

WAGES AND RETAIL PRICES OF FOOD IN 1906.

The annual investigation of the Bureau of Labor into wages and the retail prices of food, shows that in the principal manufacturing and mechanical industries of the country average wages per hour in 1906 were 4.5 per cent higher than in 1905, the regular hours of labor per week were 0.5 per cent lower, and the number of employees in the establishments investigated was 7 per cent greater. The average full-time weekly earnings per employee in 1906 were 3.9 per cent greater than in 1905.

The retail prices of food, according to consumption in representative workingmen's families, were 2.9 per cent higher in 1906 than in 1905. As the advance in wages per hour from 1905 to 1906 was greater than the advance in the retail prices of food, the purchasing power of an hour's wages, as measured by food, was greater in 1906 than in the preceding year. In 1906 the purchasing power of an hour's wages as expended for food was 1.4 per cent greater than in 1905 and the purchasing power of a full week's wages was 1 per cent greater.

As compared with the average for a ten-year period, 1890 to 1899, the average wages per hour in 1906 were 24.2 per cent higher, the number of employees in the establishments investigated was 42.9 per cent greater, and the average hours of labor per week were 4.6 per cent lower. The average earnings per employee per full week in 1906 were 18.5 per cent higher than the average earnings per full week during the ten years, 1890 to 1899.

The retail price of the principal articles of food, according to family consumption of the various articles, was 15.7 per cent higher in 1906 than the average price for the ten years, 1890 to 1899. Compared with the average for the same ten-year period, the purchasing power of an hour's wages in 1906, as measured by food, was 7.3 per cent greater, and of a full week's wages 2.4 per cent greater, the increase in the purchasing power of the full week's wages being less than the increase in the purchasing power of hourly wages because of the reduction in the hours of labor.

Correcting the Gain of a Watch Without Scratching the Spring.—Sometimes a watch gains so much that it cannot be regulated by the index. Some watchmakers scratch the spring, but this may render the spring uneven. If there is not a spare spring at hand take the spring from the collet and the stud, and place it on a slab of ground glass covered with oil-stone. It should be fixed on the slab, as if mounted on the cylinder, and pressure applied with a new and flat bouchon, turning and forming circles as large as possible, in order to prevent damage; a turn a minute is the average.

RESIDUAL PRODUCTS OF BREWING.

THE UTILIZATION OF A WASTE PRODUCT.

BREWERS' grains are widely used as cattle feed. Care must be taken to feed them as fresh as possible, because lactic acid readily develops in them and is subsequently transformed into butyric acid, acetic acid, etc. This change is detected in the grains by the absence of the clean malt odor, in place of which they acquire a decidedly sour smell. It is necessary to mix the grains with cut straw or hay, to induce the cattle to chew them. For a short time—about 14 days—grains can be kept in tubs, pressed down with boards, weighted with stones and with water poured about 4 inches deep over the grains. The tubs must be kept very clean, and after emptying, coated repeatedly with lime until it no longer turns gray (a sign of the presence of acid), but remains white. For longer storage, the grains are packed in earth silos and covered air-tight with a heavy layer of earth. The silos, however, must not be larger than will hold a week's, or at most, fourteen days' supply. Fermenting grains are an excellent fertilizer.

In the preservation of grains there are four methods to be considered. The first, drying the grains on a kiln, gives good results, but is too costly. In the second method, which is coming into use in England, the moisture is whirled out of the grains by means of a "centrifugal," into which hot steam is admitted, after which they are pressed into solid cakes which are used as feed stuff. In another method, the grains, with an admixture of suitable material, like clover, feed meal, pea and bean grits, etc., are made up into a dough and baked into a sort of bread. This bread is brown, porous, friable, and smells and tastes like fresh rye bread. It readily dissolves in water and can be fed as well dry, with other cut feeds, as in liquid form. Finally, the storage as already described, with the addition of some salt, in silos, the walls of which are built up and cemented, has also proved successful.

Residual yeast is mainly utilized in the production of compressed yeast. H. Rüdinger gives the following directions for its production:

The yeast deposited at the bottom of the fermenting tub, after the chief fermentation, is collected in a large tub, in the sides of which, at varying heights, tap holes are provided, the yeast mass being left for a few hours to itself. The yeast settles, and by opening the uppermost tap holes, a quantity of "green" (young) beer is obtained, which is either run into a storage cask or transferred to a fermenting tub for mixing with a future fermentation. After this green beer has been run off, the tub is filled up with clean water and the yeast thoroughly stirred up, allowed to settle and after about an hour the withdrawal of the liquid commenced, at first from the uppermost tap holes. The fluid that runs off first is clear, and runs to waste, but as lower holes are opened and it begins to flow off fairly turbid, it is run through a sieve, in which a coarse linen cloth is spread. This retains the greater portion of the yeast, but after a time the pores become so clogged that the fluid can pass off only very slowly; several sieves are kept in readiness, so that there may be no delay in the process.

When the yeast begins to run out as a thick fluid, the tap holes are closed and the yeast that has collected on the sieve cloths is returned to the tub. The tub is then again filled with water and treated in the same manner as before. This washing out of the yeast is continued as long as the yeast collected on the cloths possesses a decidedly bitter taste. In most instances three or four treatments with fresh water will suffice to remove the bitter taste.

The washed-out yeast is now collected and freed from water. This filtering apparatus consists of a fine hair sieve, under which several frames are placed, covered with linen cloths, stretched over them. The fluid that runs clouded through the first cloth, leaves on the cloth beneath it a part of its suspended yeast, more on the third cloth, etc., and finally flows from the lowest cloth but slightly clouded. It is collected in a tub where, in the course of a few hours, the last of the yeast is separated, in the form of a fine, slimy deposit, the supernatant fluid being as clear as water.

As the filter cloths become clogged they are set aside to drip and are replaced by others. When the cloths are all dry, the yeast appears on them as a brownish colored, soft slime, and is removed by means of a blunt-edged wooden knife-blade.

The paste thus obtained is wrapped in a closely woven cloth, this inclosed in a second cloth, and the whole placed in a screw press. The pressure at first must be gentle—the fluid must never run off clouded—but gradually, a stronger pressure may be applied. After a considerable quantity of water has been expressed from the yeast, the pressure can be steadily increased so that the mass finally removed from the pressing cloths about compares in consistency with green cheese.

To preserve the compressed yeast unchanged, it is best to cut it at once into square pieces (usually about 8 ounces to 1 pound each), to wrap it in waxed paper or tin foil, and keep it in a cool place.

To work bottom-fermentation yeast into baker's yeast, it must first be washed. The yeast is passed through a fine hair sieve, into a trough which is arranged to stand somewhat deeper in front than in the rear, so that the fluid it contains has some fall. In the center stave of this vessel holes are bored at intervals of 2 inches in the upper portion, at wider intervals toward the bottom, each closed by a spigot. The yeast is stirred into water, to which a good tablespoonful of carbonate of ammonia is added for each 26 gallons of yeast. When the yeast has settled to the bottom, the spigots are withdrawn, one after another, and the water allowed to run off. The yeast will rarely be white enough, so that the process must be repeated a second and third time, only the second time a smaller quantity of carbonated ammonia is added and the third time none at all.

This process is also employed sometimes with top fermentation yeast, only in this case a second washing usually suffices, without the addition of more of the salt. When the yeast is white enough, it is placed in filtering bags and thoroughly pressed out and sometimes partly to improve its color, sometimes to give it the consistency of a so-called short, friable article, it is kneaded up with some starch flour.

After worts can be employed to good advantage for mashing in the grist of a succeeding brewing, when the new mash is made immediately after the brewing from which the after wort is obtained. If even a few hours' delay intervenes, it is best to use this after wort together with the spargings from the grains, for the production of malt vinegar. In the same manner all other fluid brewing residues, the last of the yeast-clouded beer, etc., can be used in the manufacture of malt vinegar.

For this purpose the residues are collected in a wide but shallow vat, provided with a cover that is most conveniently located near the kettle. To start the formation of vinegar, it is only necessary to pour into the tub a few glasses of sour beer, or to throw in some "vinegar mother." After the fluid has remained a few hours in this vat, it can be drawn off into smaller tubs, placed in a room at ordinary temperature. If the vinegar is too weak, a quart of raw distilled brandy is added for each 1,000 quarts.

Dr. O. Kellner states that spent hops, on account of their composition, which is about the same as red clover hay of average quality, have been recommended as an auxiliary feed substance. As this waste product is available in large quantities and has previously been utilized in a very unpractical manner, the writer undertook to ascertain the digestibility of spent hops by a direct utilization experiment.

The results show that the digestion coefficients of the hop constituents, with the exception of the raw fat, were lower than in any of the feeding substances tested directly for digestibility. As the boiling to which the hops are subjected in brewing did not alone furnish a sufficient explanation for this result, other factors were considered. It was found that about 24 per cent of the raw fibers consisted of lignine which closely commingled with the cellulose, materially lessened the digestibility of the latter. A portion of the protein in the extracted hops was found in combination with tannic acid, which, as is well known, interferes with the working of the digestive fluids. Only the raw fat showed a normally digestive condition. Inasmuch, however, as it consists of substances, which in no respect possess the chemical composition of fat, we may conclude, as far as the nutritive value of hop-fat is concerned, that it cannot be compared with other fats.

Owing therefore to their inferior digestibility and the aversion with which animals appear to regard them, spent hops must be excluded from any very extended use as cattle feed.

This residue can best be employed as fertilizer, after any beer wort adhering to it has been removed with water for subsequent utilization in the production of beer. Small additions of spent hops to the daily feed ration are, however, not to be rejected, especially as this is said to improve the appetite of the animals. A proposition to use spent hops instead of straw in making swill and grains cake is worth considering, especially when we remember that on account of the tannic acid they contain, they may exercise a preservative effect. For the same reason, the employment of spent hops in filling silos with cut sugar beets, etc., may be recommended.

The proper treatment of malt rootlets in using them for feed and compost is to grind them, after careful screening and removing of dust, to a coarse powder. It must invariably be mixed with other feed, and can best be employed for the improvement of chopped straw feed. By grinding, the rootlets are made more soluble, and consequently more readily digestible. The same rule will apply where the screenings are to be used for fertilizer.

Experiments conducted by Ad. Fericka showed that the difference in vegetation with different fertilizers was quite considerable, and malt rootlet powder, treated with sulphuric acid, was found to be the most successful stimulant of the growth of grass. The process of treating the ground rootlets with sulphuric acid is as follows: In a large tub ground malt rootlets are scalded by slowly-admitted boiling water until a pasty mass is produced. This is allowed to stand for two hours, when the entire mass will have swelled considerably and the powder have absorbed all the water, so that none is left standing at the bottom of the tub. It is then scalded a second time, but with the addition of sulphuric acid. To 5 hundredweight of rootlets, about 10 pounds of the acid are used, added gradually to the boiling water, in which the mass is again scalded. The material thus obtained can be employed directly for fertilization, or used with good effect for the enrichment of poor compost heaps.—From the German of Dr. Theodor Koller in "Verwerthung von Abfallstoffen aller Art."

OCCURRENCE OF DIAMONDS IN ARKANSAS.*

By GEORGE F. KUNZ and HENRY S. WASHINGTON.

IN Pike County, Ark., there is a small area of peridotite which enjoys the distinction of being the first locality in North America where diamonds have been found in place, and not in river gravels or glacial deposits.

As is true of almost all peridotites, the Pike County rock weathers readily, two stages of decomposition being observable. The first consists of the mechanical disintegration of the mass into an aggregate of small, angular fragments, which still preserve nearly their original hardness, though the olivines are almost wholly altered. This passes into the stage which is of most interest in connection with the occurrence of diamonds, the solid rock being reduced to a soft, friable mass. This is either of a yellowish or, more characteristically, of a yellowish-green or light bluish-green color, the two varieties having been called locally the yellow and green earths. In these the outlines of the original olivines are still well seen, but the mineral is reduced to a soft, yellow substance, while the biotites are comparatively little changed. From the preservation of the form of the olivines it is clear that the decomposition of the rock has gone on in place, and that the yellow and green earths have not been transported from a distance.

The first diamond was discovered on August 1, 1906, by Mr. John M. Huddleston, who had purchased the land largely on account of its peculiar character, as he suspected that it contained some "mineral." Mr. Huddleston was searching, on his hands and knees, for indications of copper or lead ores, and his attention was attracted by the luster of the stone, which he recognized immediately as differing widely from the somewhat abundant small quartz crystals which are scattered over the area. The diamond, which is a white stone weighing 4½ carats, was lying among the pebbles on the surface of the thin layer of soil which overlies the green earth near the southern edge of the igneous area where the decomposed peridotite is much cut up by small gullies.

The afternoon of the same day, while riding on horseback and carefully scrutinizing the ground, he saw a second diamond lying in the ruts of the road, about 500 feet north of the first and also within the igneous area. This stone is likewise white, and weighs 3 carats.

Although he and his family searched the area over very carefully, no more diamonds were found until September 8, when Mr. Huddleston found the third, also lying among the pebbles on the surface of the soil, above the green earth, about 400 feet northeast of the place where the first was found. This stone is yellow, a flattened, triangular hexoctahedron, and weighs one-half carat.

The stones were sent to persons in Little Rock, who, recognizing the probably great importance of the discovery, immediately secured options on Mr. Huddleston's land and on considerable territory in the vicinity, including the greater part of the igneous area. They then came on to New York and conferred with one of the authors (Mr. Kunz), who was, naturally, deeply interested in the discovery. The junior author (Mr. Washington) was called in and was intrusted with the geologic and petrologic examination of the

* Abstract from a bulletin issued by the United States Department of the Interior.

locality, where he spent some time during the month of October. Pits were sunk in various places over the igneous area, the green and yellow earth was screened and panned, and a careful search was made for more diamonds on the surface, but none were discovered. The points of similarity, as well as of dissimilarity, with the South African pipes were recognized, and the conclusion was reached that the diamonds were probably derived from the peridotite; though, in view of the fact that all three had been found among the surface pebbles, which had come from the conglomerate, the possibility that this may have been their source was not excluded from consideration, and further extensive prospecting was recommended. This was subsequently done to some extent, though interfered with by bad weather, and several more diamonds were found all on the surface of the ground.

Final and absolutely definite proof that the diamonds occur in the peridotite and that those found have been derived from it was furnished by the discovery, about the middle of March, of a diamond imbedded in the green earth, about three feet below the surface, while this was being excavated for washing, a careful watch being also kept by the men for just such a discovery.

The most careful scrutiny failed to reveal any evidence that it had been artificially inserted, and no other conclusion was possible than that it was actually *in situ*. Taking all the facts into consideration, therefore, the occurrence of diamonds in the peridotite of Pike County may be regarded as unquestionable.

The number of diamonds found up to the date of writing is 130, the weights varying from one thirty-second of a carat up to 6½ carats. The majority are distorted octahedrons, a few being flattened and triangular, and a small number are almost perfect octahedrons. No cubes have been found. Most of the stones are white, a large proportion being of good water and the white of exceptional purity, finer than most African stones. A smaller number are brown; some are yellow, and several small individuals are of bort.

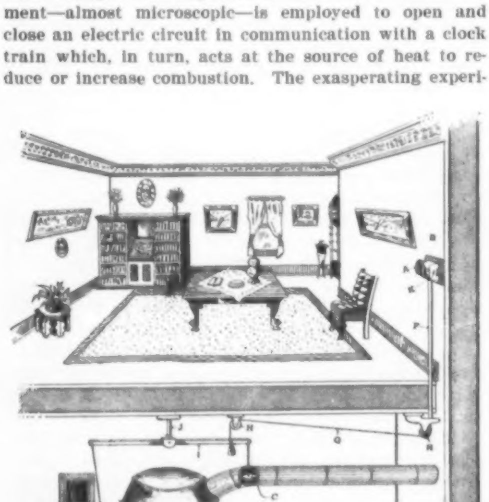
DEVICE FOR AUTOMATICALLY CONTROLLING THE HEATING OF A HOUSE.

A DESCRIPTION OF THE SYLPHON REGITHERM.

There are few lines of engineering along which more substantial progress is being made than that of artificial heating. This is especially true of the heating of residences. An essential feature of every American home is a heating system, and the degree to which this system enters into home comfort, has led heating engineers to devote much thought to this problem, with the result that to-day a modern residence heated by a vacuum vapor system, or an accelerated water system, is as far in advance of the high-pressure boiler of ten years ago as the latter was of the open grate.

One of the most recent advances in this branch of engineering has just been made by Mr. Weston M. Fulton, of Knoxville, Tenn., formerly observer in charge of the United States weather observatory in Knoxville, and instructor in meteorology and astronomy in the University of Tennessee. The inventor styles this new device "The Sylphon Regitherm." The regitherm automatically controls the temperature in houses, and thus accomplishes the two-fold end of conducing to the comfort of the occupants, and effecting a great saving of fuel by preventing those extremes of heat which are too often experienced in even the best-heated houses.

It has long been recognized by heating engineers that any system of heating, in order to be satisfactory, must be controlled, and thermostats of various kinds have been devised with this object in view, but these devices have been more or less imperfect, with the result that most house owners have preferred to endure the discomfort of a poorly regulated heating system, rather than be annoyed by a defective thermostat. The regitherm, while it is a temperature regulator, cannot be properly called a thermostat, for it is such a radical departure from the beaten path hitherto pursued that it would be misleading to style it a thermostat. In ordinary parlance a thermostat consists of one or more strips of metal, ebonite, or similar material, which undergo minute expansion or contraction, with changes in temperature, and this small movement—almost microscopic—is employed to open and close an electric circuit in communication with a clock train which, in turn, acts at the source of heat to reduce or increase combustion. The exasperating experience of a corroded electric contact point, or a "short circuit," or an exhausted battery, or a "run-down clock," are too familiar to all to merit discussion.



HOW THE REGITHERM IS INSTALLED.

Mr. Fulton's device employs no electricity, clockwork, compressed air, or other auxiliary power to complicate its operation, but draws its power entirely from the changes which take place in the atmosphere surrounding it. It controls the heat with equal efficiency, whether the source of heat be a hot-air furnace, a steam boiler, or a hot-water heater. Its construction is not complicated. In brief, it may be said to comprise a thermal motor combined with means for directing its power into useful channels. The motor consists of a collapsible and expansible vessel made of metal, and constructed with deep folds in its side walls, somewhat similar to a bellows or a Japanese lantern. This flexible wall is not built up of separate disks, but is made from a single piece of metal, so that there are no seams to come apart and cause leakage. The folds, or corrugations, besides rendering the wall flexible along its axis, also give to it a large radiating surface condensed into a very small space, thus enabling the vessel to quickly absorb and give off heat in the surrounding atmosphere. The peculiar corrugated form of the flexible wall furthermore contributes to its strength. Such a wall 5 inches in diameter and 3 inches long, although it weighs only 12 ounces, easily withstands a hydraulic pressure of 100 pounds to the square inch.

THE "REGITHERM," A HEAT CONTROLLER.

It is mainly to these peculiar physical properties of this newly-discovered collapsible and expansible vessel that the device owes its superior merits as a thermal motor. Hermetically sealed within the vessel is a small amount of volatile liquid, whose vapor changes its pressure at the rate of one-half pound per square inch for each degree of change in temperature. This liquid does not have to be replenished, but like the liquid in a thermometer, does continuous service throughout a lifetime. The end wall or "head" of the vessel measures 30 square inches; so that a change of a single degree in the temperature develops a force of 15 pounds within the motor. This force acts to expand the vessel through a distance of half an inch, and this movement is magnified eightfold in being transmitted to the dampers, thus imparting to the latter a movement of four inches. Means are provided within the regitherm to neutralize the resilience, or "spring" in the vessel, so that there is no increased resistance offered by the vessel during its expansion or contraction.

One of the illustrations shows the manner in which the regitherm operates to control the temperature of a house. Regulator *A* attaches to the wall *B* of any living room or hall of the house whose temperature is to be controlled, and connects with the dampers *C* and *D* of the heater *E* in the basement, and a change of a single degree in the temperature of the room where the device is located is sufficient to open or close a properly balanced damper of a house-heating furnace or boiler. Being freely exposed to the air of the room, it responds at once to the temperature changes. The motor operates a short lever arm at the rear, causing it to rise with rising temperature and fall with falling temperature. A small wire cable *G* leads from this lever arm through a pipe *F* to the dampers *C D* in the basement. The cable *G* passes thence around the transmission pulleys *H H* to the damper lever *I*, which is pivoted on the lower end of a support *J*, fastened to the ceiling of the basement. The dampers *C D*, of the heater *E*, are connected to the opposite ends of the lever *I*, and the regulator shifts the dampers by tilting lever *I*. For example, when the requisite temperature is reached in the house, the regulator exerts a pull on cable *G*, which tilts lever *I* and closes the draft damper *D* and opens check damper *C*, thus reducing combustion of fuel in the heater *E*. As soon as the temperature falls slightly, the regulator slackens its pull on cable *G*, thus allowing the dampers to shift in the opposite direction, and cause increased combustion of fuel. The regulator has a range of operation from 55 deg. to 80 deg. F., and it is adjusted to operate at any temperature within these limits by turning a key, which is inserted in the keyhole *K* at the regulator.

When we view the subject from a purely mathematical standpoint, it is more easy to comprehend how this novel motor can draw so much power from the surrounding atmosphere. A small room, 14 feet long, 14 feet wide, and 10 feet high, contains 1,960 cubic feet of air. If enough heat be extracted from this air to lower its temperature one thirty-fourth part of a degree, and this heat be converted into mechanical energy, it will lift a weight of about 700 pounds through a distance of one foot. The accompanying photograph illustrates in a very striking way that the regitherm is able to appropriate for its own use a large share of this abundant store of energy. As here shown, a lighted candle placed under a small motor lifted a 150-pound man several inches in a fraction of a minute.

POWER OF THE REGITHERM. LIFTING A MAN WITH THE HEAT OF A CANDLE.

THE DENSITY OF ETHER.

Speaking before the British Association Sir Oliver Lodge pointed out that the theory that an electric charge must possess the equivalent of inertia was clearly established by J. J. Thomson in 1881, and that the discovery of masses smaller than atoms was made experimentally by the same worker, and communicated in 1889. The theory that the corpuscles so discovered consisted wholly of electric charges was sustained by many people, and was clinched by the experiments of Kaufmann in 1902. The concentration of the ionic charge required to give the observed corpuscular inertia could be easily calculated; and, consequently, the size of the electric nucleus, or electron, was known. The old conception that a magnetic field was kinetic had been developed by Kelvin, Heaviside, and others,

most of whom treated it as a flow along magnetic lines; though it might also, perhaps equally well, be regarded as a flow perpendicular to them and along the Poynting vector. The former doctrine was sustained by Larmor, as in accordance with the principle of Least Action, and with the absolutely stationary character of the ether as a whole; the latter view appeared to be more consistent with the theories of J. J. Thomson. A change in motion was well known to be surrounded by a magnetic field; and the energy of the motion could be expressed in terms of the energy of this concomitant field, which again must be accounted as the kinetic energy of etherous flow. Putting these things together, and considering the ether as essentially incompressible—on the strength of the Cavendish electric experiment, the facts of gravitation and the general idea of a connecting continuous medium—the author reckoned that to deal with the ether dynamically it must be treated as having a density of the order of 10^{12} grammes per cubic centimeter. The existence of transverse waves in the interior of a fluid could only be explained on gyrostatic principles, i. e., by the kinetic or rotational elasticity of Lord Kelvin. And the internal circulatory speed of the intrinsic motion of such a fluid must be comparable with the velocity with which such waves were transmitted. Putting these things together, it followed that the intrinsic or constitutional vortex energy of the ether must be of the order 1033 ergs per cubic centimeter. Thus, every cubic millimeter of the universal ether of space must possess the equivalent of a thousand tons, and every part of it must be squirming internally with the velocity of light.—Chemical News.

THE DESIGN OF INDUCTION COILS.*

PRACTICAL HINTS FOR THE AMATEUR AND THE MANUFACTURER.

BY WILLIAM O. EDDY AND MELVILLE EASTHAM.

This article enumerates and discusses the various factors that should be considered by the maker or designer of effective and efficient induction coils, without allowing theoretical considerations to outweigh manufacturing difficulties and the cost of the construction.

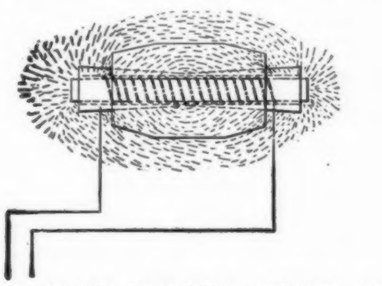


Fig. 1.—LINES OF FORCE AROUND AN INDUCTION COIL.

The object intended is to present the theory relating to the essential components of a coil and their mutual relations, as well as facts learned from experience in the building of induction coils. No attention is given to the history of the development of the coil-making art, or the enumeration of well-known early coils and data on their construction, which fills the chief space in the usual article on this subject.

The first consideration in the design of an induction coil is the purpose for which it is to be used, whether it is to be a spark coil for the ignition of the mixture in a gas engine, a large experimental coil for a physical laboratory, or a small coil for telephone work. Consideration will be given here to only that class of coils which has a separate primary and secondary, unconnected and insulated from each other, and which will be capable of giving at least a four-inch discharge between secondary terminals.

The chief application of such a coil is, at the present time, the transmitting end of a wireless telegraphy station or the exciter for the generation of Röntgen rays. It is toward the design of such coils that these notes are intended especially to apply.

For both of these two classes of work there are other considerations more important than the mere sparking length. For example, a coil with a secondary potential that will throw only a nine-inch spark will, if properly designed, give more powerful X-rays than the average sixteen-inch coil run on the same circuit, and using the same amount of power. Manufacturers have in the past prided themselves on being able to obtain a certain spark length with a minimum number of pounds of secondary winding. The only claim for recognition that such a coil has is that it can show a long spark jumping between terminals, but for efficient and effective usefulness it has none.

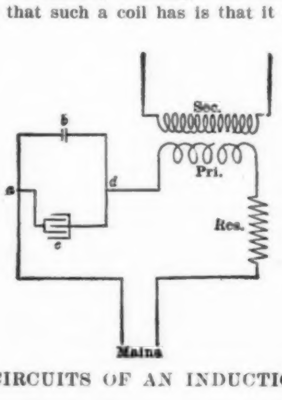


Fig. 2.—CIRCUITS OF AN INDUCTION COIL.

It is deplorable that the rating of induction coils should be only by the spark length. It would be just as sensible to rate transformers only by the potential of their secondaries, and to speak of a 40,000-volt transformer without stating whether its capacity is one-half of 5,000 kilowatts. The explanation of the present plight seems to be that for years the high-potential induction coil has been a scientific toy, an apparatus for producing only a long spark for spectacular or experimental purposes, without reference to the efficiency of transformation or the amount of power required. Being worked only for a short time, the heating of the coil was not a consideration and the strength of the secondary current was unimportant. The makers bent their competitive energies toward that design which would give the highest potential with the least weight of wire and size of coil. These traditional considerations have, until recently, been the gospel of the induction coil builder, and the small amount of real knowledge of the requirements and the underlying principles of design possessed by the average manufacturer is truly remarkable.

Now that the induction coil has become an apparatus of commercial value it is high time that it had a real and definite rating which should show in some way for a stated primary input the output of the secondary, as well as its sparking distance; and also the safe watt capacity of the coil with reference to a time and temperature factor.

The design of an induction coil is more or less of a compromise and involves several problems: (1) The varying conditions under which the coil is to be used, make it necessary to design for a wide range of operation; (2) each separate factor cannot be designed for its own best efficiency in one direction without at the same time seriously influencing another part of the coil or another function of the same part; (3) the cost and manufacturing expediency must be carefully considered. The first problem is solved in part by designing for the average work required of the coil and by making the inductance of the primary and the capacity of the condenser each adjustable. This adjustability feature is too often neglected, although the advantages usually outweigh the disadvantages that can be brought against it. It is one of the aims of this article to discuss the second problem, leaving out those theoretical considerations which are impractical from the standpoint of the third problem.

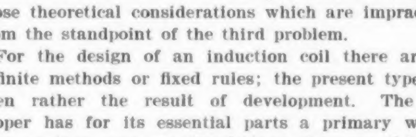


Fig. 3.—PRIMARY AND SECONDARY CURRENTS WITH SLOW INTERRUPTER.

For the design of an induction coil there are no definite methods or fixed rules; the present type has been rather the result of development. The coil proper has for its essential parts a primary wound over an iron core; an insulating tube over this primary, and a secondary winding outside of the insulating tube. These essential parts will be discussed separately.

THE CORE.

Closed magnetic circuits for induction coils are not practical because the magnetism will not die down with sufficient rapidity, while partly closed circuits of the hedgehog and I types have not proved as yet entirely satisfactory, although development along this direction may be expected. Various attempts to use finely divided iron for closing the circuit have not been successful, for though iron in this state will follow rapid oscillations, it has such a low permeability that its merits do not balance its disadvantages.

The core should be composed of a bundle of soft iron wires, of as high a permeability as possible, in order to be capable of receiving a high degree of magnetization and thus create a powerful field. The character of the iron should be such that its hysteresis loss is small.

The smaller the wire the smaller the eddy-current losses, and the less the heating of the core, but the less effective it will be since, for a given cross-section, there is a less amount of iron, due to the greater amount of oxidized surface, and the permeability of the core as a whole is therefore diminished. If a larger diameter of core be used to atone for this, there will be required to wind around it, per turn, a greater length of secondary wire with its consequent disadvantages. Experience seems to indicate that the best average size of core wire is about No. 22 B. & S.

The strength of the eddy currents generated in the core is proportional to the speed of interrupter in the primary circuit. Therefore, the resistance in the path of these currents should be increased at the expense of space, the higher the speed of interrupter to be used; and for this reason, for an extremely rapid break, even a layer of rust on the wire may not be sufficient, and each wire may be dipped in some kind of insulating varnish. With respect to the size of the core also we should consider the interrupter to be used. If it be a rapid one it may be too fast for a core of large diameter, which requires a longer time or a stronger current to fully magnetize it, and near saturation is the best point at which to work. Again, the magnetism penetrates from the outside, and it is analogous to the "skin effect" on a conductor carrying high-frequency currents, and may not reach the center of the core at all for an extremely rapid vibrator, in which case a hollow cylinder would serve as well as though it were solid. These points, together with the fact that the slower the interrupter the less the hysteresis losses, argue for a slower interrupter. This point, however, will be taken up later.

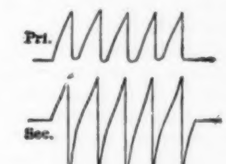
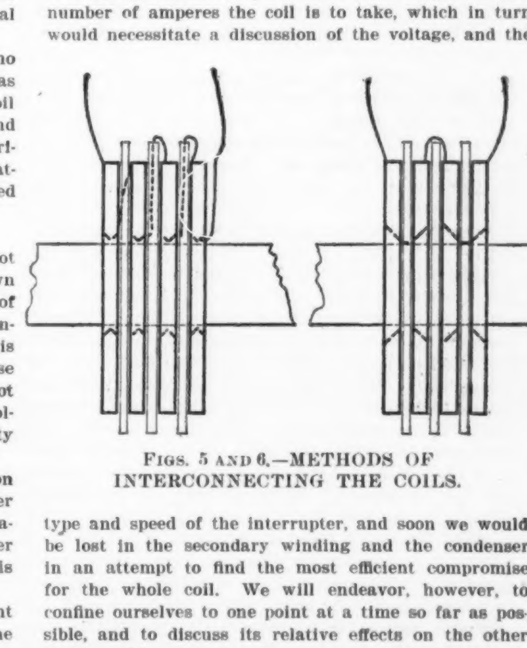


Fig. 4.—PRIMARY AND SECONDARY CURRENTS WITH RAPID INTERRUPTER.

THE PRIMARY AND THE CORE.

The primary and the core are so intimately related that they should be discussed together; a change in either will necessitate a change in the other. Consider an open magnetic circuit, straight and cylindrical in form, which for its magnetism will be dependent upon the number of ampere-turns surrounding it. This factor being the product of the current and the number of convolutions of wire, attention must be paid to the number of amperes the coil is to take, which in turn would necessitate a discussion of the voltage, and the type and speed of the interrupter, and soon we would be lost in the secondary winding and the condenser in an attempt to find the most efficient compromise for the whole coil. We will endeavor, however, to confine ourselves to one point at a time so far as possible, and to discuss its relative effects on the other factors. We will, therefore, assume that the current is a fixed quantity, which means that we will have to give for the required magnetization a definite number of turns to be wound over the core, and it is important



Figs. 5 and 6.—METHODS OF INTERCONNECTING THE COILS.

* Reprinted from the Electrical World.

that this primary winding should take up the least possible amount of cross-sectional space, so that the secondary may be placed close to the core where the field is strongest.

The dotted lines in Fig. 1 show the lines of force as they would be found by the well-known method of allowing iron filings to arrange themselves about a straight open-circuited iron core magnetized by a winding, as shown. It is seen from the diagram that most of the lines bend at the end of the winding to return to the opposite pole by the shortest path without emanating from the extreme end of the core; thus we see that there is no object in having the core much longer than the primary winding, which should extend nearly its full length.

In experimenting with the primary and core the effect of the secondary may be considered almost negligible if it be kept open-circuited, so that no sparks may pass. If current be allowed to flow in the secondary the inductance of the system is decreased, and with the terminals short-circuited the mutual induction between the primary and secondary renders the inductance of the primary circuit of little comparative value, and calculations and measurements of the primary inductance alone are almost worthless. In considering the design of the primary and core we must take into account the volume of current that is to be used from the secondary, and that design which will give the longest spark across the resistance of the air is not the best with a diff... resistance or where current is used to charge a condenser.

Some experimenters have suggested that the best ratio of the diameter of the core to its length should be about one to twelve, but they seem to have been aiming only for great length of spark; a better ratio for a coil for average work would be from six to ten times the diameter for the length of the core. This ratio should depend on the interrupter and the size of the coil, and should not be the same for a large as for a small one.

Fig. 3 shows the curves of the primary current and the resulting secondary current under nearly perfect conditions with a slow interrupter; the curve for the primary being above the line, and that for the secondary below. The ordinates of these curves represent the increase and decay of the currents, while the abscissas represent time intervals. It is only the magnetic change at "break" that produces useful current in the secondary, the magnetic change at "make" giving a reverse current that we would gladly dispense with if possible. If there were no iron in the circuit the current would reach its full value practically immediately, as shown by the dotted line on the representation of the first wave of the primary curve. The greater the inductance of the circuit the slower the current rises, and as here shown it is allowed, before "break" takes place, to reach practically its full value and become constant with the core fully magnetized; during this time the reverse current in the secondary has become zero. The breaking of the circuit is represented as being instantaneous—which is too ideal to be true—and as this occurs the primary current becomes zero while the magnetic field "collapses," throwing its energy into the generation of the useful current in the secondary, which in turn is allowed to become zero before "make" again takes place. The dotted line on the second wave represents ineffectual attempts to make and break the circuit by the average vibrating hammer interrupter; this of course will have its effect on the wave form of the secondary. The dotted line on the third wave represents the oscillatory discharge of the condenser across the gap, as found with the Braun cathode ray tube.

It will be readily appreciated that if the interrupter on this same circuit works too fast, the make-and-break curves of current will run into each other, break occurring before the primary current has reached its maximum value and before the reverse current in the secondary has died away, the next make reversing part of the useful secondary current and the whole coil working inefficiently.

Fig. 4 represents the primary and secondary curves with a rapid electrolytic interrupter in an extreme case as found by Armagnat in a most interesting set of tracings obtained with a Blondel oscillograph. With this rapid type of interrupter the curve of increase of the current in the primary is very steep and is sharply reversed when the break occurs. This rapid increase causes the reverse current which is produced in the secondary at "make" and also its sparking distance to be, as illustrated for an extreme case, nearly as great as at "break." Of course with every coil the current in the secondary tends to prevent the swift demagnetization of the core at break. With the electrolytic interrupter the reverse current is lessened with sufficient self-inductance in the primary circuit, either by a larger core or by ample primary turns.

In this connection we might call attention to the point that the speed of break is entirely different from the rapidity of oscillation of the interrupter. The latter will determine the number of discharges that can be obtained from the coil per second, and, usually, the time allowed for magnetizing the core, but a rapid interrupter does not necessarily mean a rapid speed of break, which cannot in any case be too rapid, the ideal condition being to have this absolutely instantaneous.

A rapid mechanical break should be so designed as to give as long time as possible after the circuit is made instead of having the extra interval come after it is broken. When the "make" is short the amperage must be great in order to sufficiently magnetize the core in so short a space of time. This is obtained by running the coil on a higher voltage for a rapid interrupter or by cutting resistance out of the primary circuit.

The faster the interruption the harder it is on the interrupter, although the observed primary current is smaller. This is a point usually not realized by manufacturers, since the ammeter in the primary circuit measures only the average current, and does not register this excessive current which flows only for a brief space of time. Often the secondary voltage may be increased by increasing the speed of the interrupter; but this is because with the increased speed the speed of "break" is increased also.

A slow interrupter with a quick break will give excellent results in an X-ray tube provided it is not so slow as to show a flickering with the fluoroscope. A larger amount of current can be used with a tube across the secondary than on open circuit, since the effect of the secondary when delivering current is to lessen the inductive effect of the primary and allow the primary current to reach its maximum value in a shorter space of time. An extremely rapid interrupter is not advantageous in wireless telegraph work for reasons that will be mentioned later. The importance of considering the nature of the interrupter in designing a coil may be seen by the frequency with which it is necessary to mention it.

Of course the curves shown in Figs. 3 and 4 would be influenced by the character of the load on the secondary and the tracings that would be obtained from the average coil as ordinarily used would be far from ideal.

To sum up the discussion of the primary and the core the writers suggest or recommend a larger core in both length and diameter and a larger number of ampere-turns than has been the custom in standard commercial practice, thus producing a powerful field which is the first essential in the design of a coil which is expected to deliver a large amount of energy and do useful work. It is noteworthy that in some of the more recent models this course has been taken, and the coils made according to the new design show improved results.

THE PRIMARY.

The primary winding should have regulating taps brought out from it at least at the end of each layer. The greater the number of primary turns, the larger must be the number of secondary turns to obtain a given potential.

The primary wire should be of a size large enough to carry, in its inclosed position, the maximum amount of current that the coil is expected to handle, although induction coils are seldom worked at their full capacity for any great length of time. The larger the amount of current put through the primary, the greater will be the power output, and also the potential. Other than for its heating effect the resistance of this winding is of little importance, since the inductive reactance far outweighs the ohmic resistance in its choking effect. Moreover, as shown in the theoretical connection diagram (Fig. 2), the coil is worked usually with a regulating rheostat in series with the primary.

Wire of square cross-section has been used, since it gives greater volume of copper for a given winding space, but owing to manufacturing expediency such wire is now abandoned in most cases, because of the difficulty of handling square wire on account of the danger that the insulation may become injured at the corners.

It has been found that a coil working on a 110-volt circuit may have induced a "kick-back" potential across the primary of over 2,000 volts; it is, therefore, necessary to keep the primary layers well insulated and to have sufficient insulation between the winding and the core.

For a twelve-inch coil—which has been considered somewhat a standard—which is to be operated from batteries where the volume of current is large, the size of wire should be from No. 8 to No. 10 B. & S.; while the same coil to be operated from the 110-volt circuit with small current would require No. 12 or No. 13. The number of layers and dimensions of core depend, as mentioned above, on the interrupter, the amount of primary current and the work required from the secondary.

(To be continued.)

The navigable dimensions of the Suez Canal are now practically double what they were twenty years ago, the superficies of the vertical profile having been considerably increased.

INTERACTION OF ABSTRACT SCIENCE AND ITS APPLICATIONS.

By Prof. Silvanus P. Thompson.

In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasized in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Faraday, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact or a new physical relation, ceased from busying himself with it and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also the proposition that sooner or later the practical applications are bound to follow on upon the discovery, it yet remains true that in this thing the temperament of the discoverer counts for something. There are scientific investigators who cannot pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply cannot work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer—namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

There is, however, another aspect of the relation between pure and applied science, the significance of which has not been hitherto so much emphasized, but yet is none the less real—the reaction upon science and upon scientific discovery of the industrial applications. For while pure science breeds useful inventions, it is none the less true that the industrial development of useful inventions fosters the progress of pure science. No one who is conversant with the history, for example, of optics can doubt that the invention of the telescope and the desire to perfect it were the principal factors in the outburst of optical science which we associate with the names of Newton, Huygens, and Euler. The practical application, which we know was in the minds of each of these men, must surely have been the impelling motive that caused them to concentrate on abstract optics their great and exceptional powers of thought. It was in the quest—the hopeless quest—of the philosopher's stone and the elixir of life that the foundations of the science of chemistry were laid. The invention of the art of photography has given immense assistance to sciences as widely apart as meteorology, ethnology, astronomy, zoology, and spectroscopy. Of the laws of heat men were profoundly ignorant until the invention of the steam engine compelled scientific investigation; and the new science of thermodynamics was born. Had there been no industrial development of the steam engine, is it at all likely that the world would ever have been enriched with the scientific researches of Rankine, Joule, Regnault, Hirn, or James Thomson? The magnet had been known for centuries, yet the study of it was utterly neglected until the application of it in the mariners' compass gave the incentive for research.

The history of electric telegraphy furnishes a very striking example of this reflex influence of industrial applications. The discovery of the electric current by Volta, and the investigation of its properties appear to have been stimulated by the medical properties attributed in the preceding fifty years to electric discharges. But, once the current had been discovered, a new incentive arose in the dim possibility it suggested of transmitting signals to a distance. This was certainly a possibility, even when only the chemical effects of the current had yet been found out. Not, however, until the magnetic effects of the current had been discovered and investigated did telegraphy assume commercial shape at the hands of Cooke and Wheatstone in England, and of Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers; exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry, and a host of less famous workers. But no sooner had the telegraph become of industrial importance,

with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary; new and delicate instruments must be devised; means of accurate measurement heretofore undreamed of must be found; standards for the comparison of electrical quantities must be created; and the laws governing the operations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last but not least by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics or geometry; his electromagnetic theory of light would never have leaped into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the British Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that for the most part this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action, ceases here to be applicable, as indeed it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the organism—not in such a way as to oppose growth, but promote it. So is it with the development of pure science and its practical applications.

In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to the probability of a very great and rapid advance in that fascinating branch of pure science at no distant date.—Abstracted from a paper read before the British Association for the Advancement of Science.

TANTALUM.*

THE WONDERFUL PROPERTIES OF A NEWLY APPLIED METAL.

Until recently, the metal tantalum was almost unknown to the greater number of chemists, and was considered as a laboratory specimen. There were but few scientists who possessed more than ten or twenty grains of it. In order to study its compounds, Joly was obliged to collect the old residues of Sainte Claire Deville's preparations, and with only 100 grammes of tantalic acid, Marignac carried out his remarkable researches upon this metal. Quite recently, M. Henri Moissan reduced by the electric arc several pounds of tantalic acid, but the tantalum obtained thus was hard and brittle and almost infusible. It remained without application, and its ores, which were not sought for, were of a high price. As soon as industrial needs led to the use of the refractory properties of tantalum, this condition changed, and mines of tantalum ore have been discovered in many places to meet the demands of the industry. The metal which was extremely rare and costly is now valued less than silver, or about $5 a pound. This sudden change is due to the use of the metal for electric lighting. The duration of carbon filaments is limited. Although carbon is one of the most refractory bodies known, since it can hardly be melted, it volatilizes at a high heat very easily, and this causes the blackening of incandescent lamps. At the same time the filament becomes thinner. These disadvantages could be overcome by an increase of resistance which would cause an increase of temperature and a greater glow, if the temperature coefficient of carbon were not negative. In fact, its conductivity increases with the heat.

Thus it is not possible to increase the glow of a carbon lamp by using a higher current. However, we wish precisely to increase the heat so as to give a better light for incandescent lamps. In fact, a body is whiter and more brilliant as the heat increases. We thus see the great interest given by the use of a refractory and non-volatile filament which can be used at a high heat. Mr. Lummer has drawn a curve representing the energy emitted for each wave-length for a carbon filament. The maximum, a sharp point on the curve, corresponds to waves having 1.5 μ length, or in the infra-red. To increase the yield, we must increase the temperature greatly so as to displace the maximum on the side of the small wave-length, or toward the visible rays.

The researches of M. Von Bolton are of great interest. We find that inventors prepared refractory and strong filaments which could stand 2,000 deg. C. (3,632 deg. F.). About the same time the Nernst lamp appeared, using a mixture of rare earths, also Dr. Auer's osmium lamp. The brightness and yield of both were above the carbon lamp, but both had grave disadvantages. During this time the Siemens & Halske firm had one of their engineers seek for a refractory metal, more abundant than osmium, whose total production is not over 12 pounds annually and without hope of an increase. Finding that vanadium is not refractory enough and that it is brittle and not easy to draw into wire, he sought an analogous element which would be better. Like vanadium, two metals, colombium and tantalum, form an oxide which plays the part of an acid, of formula $(M)_2O_5$. But the tantalic and colombic acids are white and non-conducting. By mixing them with paraffin and heating to 1,700 deg. C. (3,092 deg. F.) in carbon powder, we can reduce these oxides and obtain brown oxides which are good conductors. The metals can be prepared from these. Colombium is rather ductile and melts about 1,950 deg. C. (3,542 deg. F.). Tantalum, which is very ductile, is easily laminated and drawn into wire. Its melting point is near 2,300 deg. C. (4,172 deg. F.). Thus we find it to be the refractory and ductile metal sought for.

The chemist Ekeberg was the first to discover the metal, but only in the form of its acid. This he found in fossil matter, and also in minerals from Kimito in Finland. It was found that the new acid from these sources had the remarkable property of being insoluble in all the acids, and only dissolved in the alkalis or carbonates. Ekeberg recognized the presence of a new metal, and he proposed to call it tantalum, from the legend of Tantalus, seeing that it was surrounded by acids without having any effect from them.

As regards the metal, we find that Gahn, Berzelius, and others succeeded in reducing the oxide for the first time in 1816 and a few years later Berzelius reduced the fluo-tantalate of potassium, by potassium. Rose also obtained the metal by a similar method, but in an impure state, and the black powder contained but 55 per cent of it. In 1902 Henri Moissan sought to reduce tantalic acid by carbon in the electric furnace, and obtained thus a nearly pure metal containing 0.5 per cent of carbon. But even this amount of carbon changed its properties, so that the nearly pure metal free from carbon obtained by Von Bolton is quite different. The latter may be drawn into wire, but the process is a difficult one and cannot be used on a large scale. He then succeeded in obtaining a nearly pure metal by perfecting the process of Berzelius and Rose. In spite of a small percentage of impurities, the metal has about the same properties as the last mentioned. Its density is higher than was formerly attributed to it, being 14.05. When rolled and melted in the form of bars, it has a specific gravity of 16.64. Its ductility and tenacity are very high. It can be rolled and drawn into wires of 0.03 millimeter gage. When in the form of 1 millimeter (0.04 inch) wire, its tensile strength is 205 pounds per square millimeter (132,000 pounds per square inch) and it has thus the highest tenacity next to iron. But the least trace of impurity, oxygen, hydrogen, and especially carbon, changes its properties completely, and above all its ductility. In any case the metal is quite hard. A sheet of it 0.04 inch thick was drilled by a diamond drill for three days and three nights at a speed of 5,000 revolutions per minute, and the hole was found to reach only one-quarter of the thickness.

From a chemical standpoint, tantalum shows a remarkable resistance to acids. Sulphuric, nitric, hydrochloric acid, etc., have no action on it, even hot. Hydrofluoric acid is the only one which attacks it. Hydrogen combines easily with tantalum. When heated in air, the metal does not burn, as in the case of magnesium. At 400 deg. C. (752 deg. F.) it becomes yellow by formation of a layer of oxide which protects it, and we may heat the metal in strips to a bright red without burning. In a rarefied atmosphere, fine wires do not burn when the pressure is below 0.8 inch of mercury, but they burn in air without flame.

Coming to the uses of tantalum, we find that the useful properties just mentioned have given this metal a number of applications, and there have been as many as two hundred patents secured for different uses. The first of these was for incandescent lamp filaments, and at present it is this industry which consumes the greatest amount. Passing over the question of the tantalum filament, which has already been well discussed, we remark that its use as a filament shows especially the path which can be followed in the future, and on all sides new lamps have appeared with filaments formed of titanium, tungsten, zirconium, or of carbides or alloys of these refractory metals. A new development has been given to the incandescent lamp at the moment when the Welsbach burner threatened to supplant it. Perhaps the struggle may end in favor of the incandescent lamp.

The numerous properties of tantalum have been employed for other purposes. We may mention the manufacture of burnishers, dies, and drills in tantalum, where we utilize its hardness, comparable to the diamond, joined to its great ductility. The metal is also used for rectifying alternating currents. For tensions below 120 volts, two electrodes of tantalum plunged in sulphuric acid stop the current entirely. If we replace one of the electrodes by a platinum plate, the current will pass, but only in one direction. One of the most interesting uses of the metal is the following. Seeing that it is not attacked by acids nor oxidized at the usual temperature, this metal can be considered as equal to gold or platinum as to resistance to chemical agents. It has the advantage over them of being hard and resistant, especially when slightly carbureted, and is also much cheaper. Thus metal pens can be made of tantalum. Such is the subject of an English patent secured by Siemens & Halske. The pens are made of tantalum pure or alloyed containing 95 to 98 per cent of tantalum and 2 to 5 per cent of tungsten or iron. They always add 0.1 per cent carbon to harden the metal. This is done by cementation, heating the pens in carbon powder. It seems certain that tantalum will soon be used in metallurgy. Berzelius in 1816 showed that it could be alloyed with other metals. By reducing its oxide containing tungstic acid, we obtain an alloy resembling tantalum, but more compact and harder, and it is easily polished. Tantalum oxide is reduced by iron at a high heat. We secure a partly melted alloy which scratches glass and resembles cast iron.

Quite recently, M. Von Bolton showed that an alloy of iron and tantalum containing from 5 to 10 per cent tantalum gave after fusion a very hard and ductile regulus. He adds that tantalum acts upon iron like vanadium. With molybdenum and tungsten, the alloys thus obtained are brittle for a value of tantalum above 5 per cent and quite ductile for a lower proportion. They can even be drawn into wires of 0.1 millimeter. It is thus possible that before long we will begin to utilize the valuable properties which tantalum gives to iron. The constant presence of colombium in greater or less quantities in all the tantalum ores and the impossibility in practice to separate these two bodies are not to be considered as obstacles here. M. Von Bolton, in studying colombium with the same care as tantalum, found that colombium and iron can be alloyed in all proportions. The hardness of the alloy is greater than with tantalum, and its ductility is less.

We thus see, in sum, that the action of colombium on iron lies between that of vanadium and tantalum. Consequently, metallurgy now possesses a whole series of bodies, which can be utilized. According to the author's recent researches, it seems that with tantalum and even with colombium we can prepare different steels which are extremely hard, but are also ductile, but we should incorporate these metals in soft steels, and thus we avoid the harmful action of an excess of carbon. Tantalum and colombium in fact are found to absorb carbon when there is a high proportion of it, and form complex and hard carbides which are brittle and refractory, thus recalling the action of vanadium, but with this difference that the complex carbides of colombium or tantalum are of the same density or else heavier than the steel. Such a steel which is very hard as well as ductile will find many uses. As soon as metallurgists become interested in the question, it will be easy to secure alloys of tantalum and colombium in high proportion for such uses. M. Girod, the well-known French electro-metallurgist, who makes a specialty of alloys, has now undertaken to manufacture these new alloys in his works at Ugine and produces them in the electric furnace.

It may be asked if the rarity of the metal will not prevent its extensive application in the arts, but we

* Abstracted from an article by Paul Nicolardot in Revue Scientifique.

find that a large supply is to be had from different countries. Passing over the finds which were made in the early history of the metal, tantalum is known to exist in a great number of minerals, generally accompanied by colombium. The only exceptions are the mineral tantalite and the melanocerites of Barkewig, Norway. In general, the minerals containing the metal are tantalo-colombates or titano-tantalates. Among the former are the tantalites, whose general formula is $(FeO, MnO)\ m\ (Cb_2O_5)\ n\ (Ta_2O_5)$, in which the proportion of colombium varies between the colombite without tantalum to the brown powder of tantalite or skogböllite without colombium. The yttrotantalite is a tantalate of yttria containing colombium. The mineral fergusonite contains a much greater amount of the latter, and in the samarskite the amount of tantalum is still lower. As regards the class of titano-tantalates, these are the polycrase and the æschynite. The true tantalum ores are the tantalates. They were found at first in Finland, in Sweden, in Norway, and elsewhere. They are found in France and Mexico, as well as in Greenland and Australia. In the latter country and in the United States we find the most extensive workings.

CABLE-ASSISTED TRAINS UPON A SCOTTISH RAILROAD.

A CURIOUS METHOD OF SECURING ECONOMY.

The accompanying illustration shows an interesting and novel means of assisting trains up a severe gradient, which is still practised in Scotland. This grade, known as the Cowlairs Incline, upon the Edinburgh and Glasgow trunk road of the North British Railroad, extends from Cowlairs Station to the terminus at Queen Street Station, Glasgow, and the distance is approximately 1¼ miles. This incline was constructed in 1842, and for about one-half the distance it is tunneled through rock. The greater part of the gradient is 1 in 41, and the summit at Cowlairs is 150 feet above Queen Street Station. The rise commences practically from the end of the latter station, being 1 in 150 for 180 feet, increasing to 1 in 51 for a further 270 feet, followed by a stretch of 1,360 feet at 1 in 43, after which comes the steepest section of the rise at 1 in 41 to within a distance of 210 feet from the top of the bank, where it eases off to 1 in 210 for the remaining 540 feet. Under these circumstances it is impossible for a train, when heavily loaded, leaving the station below, to surmount the bank without extraneous assistance, and this is provided by means of a cable. When first opened, the incline was operated by a hempen rope, but the increase in the weight of trains demanded ultimately the use of a wire cable, and this arrangement is still in vogue. The cable is endless, made in one piece three miles in length by five inches in circumference, and weighs about 20 tons. The rope is operated by a stationary winding engine of 650 horse-power located at Cowlairs. It is of the beam type, and owing to the many novel features incorporated in its design, ranks as one of the most interesting engines of this type at work in Great Britain today. The cable itself is carried over pulleys fixed between the rails, and the average weight of the trains hauled up is about 200 tons. The cable extends along both up and down roads, but naturally is not used in connection with trains passing down the incline.

The cable is so arranged that when the train reaches the summit of the incline, and can thus proceed under its own power, the cable attachment is dropped without stopping the train. The *modus operandi* is as follows: In all cases, before the trains leave the mouth of the tunnel at the Queen Street Station at the foot of the bank, the endless wire cable is attached to the drawhook of the locomotive by means of a messenger rope, and the signal to start is given by bell communication to the signal operator at Cowlairs Station above, who in turn causes a steam whistle in the stationary winding engine house to sound. On receipt of this signal the winding engine is set in operation, and the haulage of the train commenced, the locomotive meanwhile assisting with its own power. One end of the messenger rope is divided into two parts, each of which is twisted firmly round the endless wire cable, while the other end is attached to the front coupling of the locomotive hauling the train, which is provided with an inverted hook. While the haulage action is in progress the cable is drawn taut under the tension imposed, and by means of a dial in the winding engine house at Cowlairs the engineer thereat is able to follow the progress of the train up the incline, this being automatically indicated by the revolutions of the winding engine. When the pointer of this indicator gains a certain point corresponding to the position of the train at the summit of the bank, the engineer shuts off steam and stops the winding engine. At this juncture the locomotive is in full steam on the level, and as the incline cable slackens, the messenger rope drops from the inverted hook attached to the engine coupling. Simultaneously one of the brakemen on the train disconnects the slip coupling of the brake trucks at the rear end of the train, thereby releasing the latter entirely from the cable, and the train continues its way without any stop or slackening of speed, as if it had ascended the incline under its own steam entirely. Although at first sight this haulage arrangement may seem somewhat intricate, it is actually very simple, and constitutes one of the most economical means for enabling a train to negotiate what would otherwise be an impossible gradient with a normal load.

PASSENGER TRAIN LEAVING GLASGOW; ASSISTED UP A STEEP GRADIENT BY A CABLE.

INTERIOR OF THE CABLE HOUSE; SHOWING THE BEAM ENGINE WHICH WINDS THE CABLE.

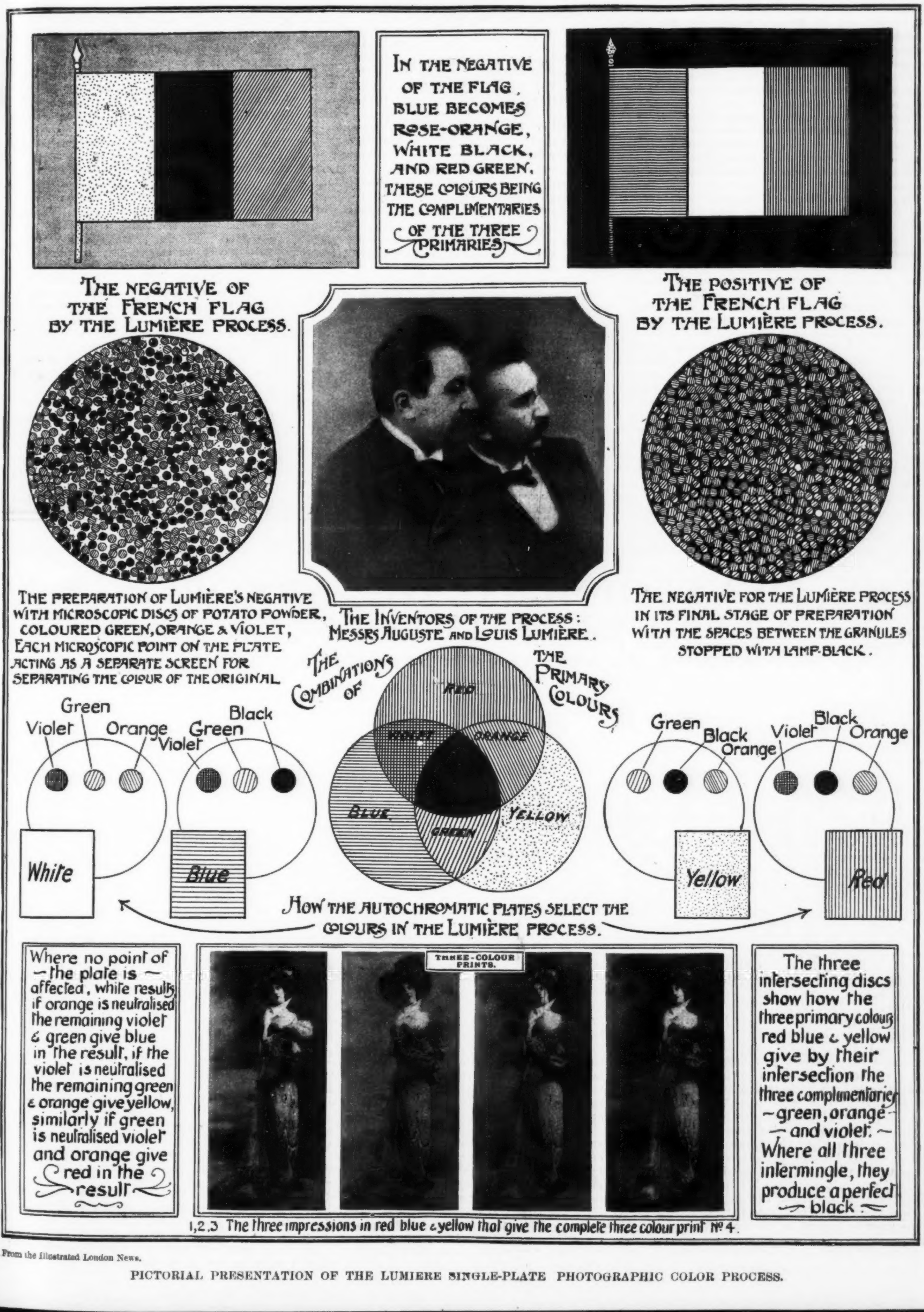
CABLE-ASSISTED TRAINS UPON A SCOTTISH RAILROAD.

ON THE VARIABILITY IN THE PRODUCTS RESULTING FROM CHANGES IN RADIUM EMANATION.

Speaking before the British Association Sir William Ramsay pointed out that radium, actinium, and thorium all yield helium, and then proceeded to describe the results of experiments which are nothing short of remarkable. It is known, of course, that the emanation decomposes water with the liberation of excess of hydrogen, but where this excess of hydrogen comes from nobody knows. Sir William Ramsay exposed a solution of copper sulphate to the emanation for about a month, and at the end of that time the residue obtained gave the spectra of both sodium and lithium. The experiments were repeated three times, and the results were perfectly consistent in each case. The presence of sodium was not, of course, surprising, as the containing vessels used were composed of glass, but all the materials were tested for lithium, and there was not a trace before the experiments were commenced. Nevertheless, he expressed a doubt as to whether the quantity of sodium found could have all come from the glass, and he is going to undertake further investigations in this direction. His next experiment was with copper nitrate, when lithium was again detected after a solution had been exposed to the emanation. Fresh copper nitrate not so treated with the emanation showed no sign of the presence of lithium. In both cases, however, sodium sulphate was detected, but the treated substance showed just twice as much (1.6 milligrammes) as the untreated substance. On evaporating water treated with the emanation 0.3 milligramme of solid was obtained, while the inactive gas produced was neon with a trace of helium. Gases from the treated copper nitrate solution contained argon, with possibly a trace of neon. He remarked that 1 cubic centimeter of emanation gives off three and a half million times as much energy as 1 cubic centimeter of a mixture of hydrogen and oxygen when exploded, and suggested that some of this vast amount of energy might account for the presence of the elements which he had found.—Chemical News.

THE LUMIÈRE SINGLE-PLATE PHOTOGRAPHIC COLOR PROCESS.

SINCE the introduction of the autochrome or self-color photographic plate early in the summer of this year by the Lumière Brothers in Paris, France, their use in England has confirmed the value of the improvement beyond question. Pictorial photographers are able to secure just the sort of color gradations



From the Illustrated London News.

PICTORIAL PRESENTATION OF THE LUMIERE SINGLE-PLATE PHOTOGRAPHIC COLOR PROCESS.

they desire, and speak highly of the plate as supplying an easy method of securing pleasing results if rightly used. Considerable investigation has shown that the size of the minute starch particles are about 0.015 of a millimeter in diameter, or 1/2,500 part of an inch, and that the proportion of coloring is about four of green-colored particles to three of orange and violet particles. They are so fine as to resemble the minute particles of flour. The starch is converted into round particles (potato starch is preferred), then each set is colored, and the different colored sets are commingled together in a special machine, crushed somewhat, and mixed with an adhering film and coated on a plate. Over this is coated the sensitive emulsion. The light passes through the glass side of the plate through the colored film, impinging upon the under side of the sensitive film.

The illustration on the preceding page shows the appearance of the arrangement of the colored particles as observed in the microscope. From Photography we take a description of the formula in English measures.

It is good policy to start on some simple still life subject, flowers, for example, or, even better, fruit. Because fruit will keep still indefinitely, and will allow of a reasonably small stop being used. A dull gray is a good background, as it clashes with none of the colors, and is also a very fine test for the plate. Remember, there is no test for a color process like black, white, and gray; and when these can be got with reasonable purity, all else follows almost as a matter of course. Having got the subject, and it is well to see at first, at least, that there is a good range of color in it—blues and greens, as well as yellows and reds—see that a white reflector is provided on the shadow side to counteract the strong side lighting, almost inevitable indoors. Place beside the subject the Watkins meter, and note how long it takes to darken to the standard tint. Either reverse the ground-glass to allow for exposing the plate through the glass, or else after focusing rack the camera in—*not out*—for a space equal to the thickness of the glass of an ordinary half-plate negative. Stop to f/22, and expose for eight times as long as it took the paper to darken. If the light is very changeable, in order to run no risks, it is well to sit down as near the subject as convenient and measure off the exposure with the actinometer, pulling out a fresh piece of paper as soon as the standard tint is reached until eight have been so measured off. Before starting to develop see that all the solutions are ready, as if one has to keep the plate wet while one or other is made up there is a risk of failure. If these instructions are carefully followed, there should be no hitch, and the first plate should be enough to lead the photographer on to the fresh fields and pastures new which this wonderful process has opened to him. If the picture so obtained is thin and light, the plate has been over-exposed; if heavy and dull, it has been under-exposed.

A and B.—First Development.

A.—Spirits of wine (not methylated spirit)	10	ounces
Pyro	160	grains
B.—Water	8	ounces
Potassium bromide	135	grains
Liq. ammonia fort. (nominally .880)	400	minims

C.—Reversal.

Potassium permanganate	1	drachm
Water	80	ounces
Strong sulphuric acid	5	drachms

D.—Second Development.

Amidol	2½	grains
Sodium sulphite (crystals)	15	grains
Water	1	ounce

As this solution keeps very badly, the composition per ounce is given, and the worker is advised not to make up more than he expects he can use in two or three days at most.

E.—Oxidation.

This solution is made by taking 3 drachms of C and diluting it with water to make 1 pint.

F and G.—Intensification.

F.—Citric acid	26	grains
Water	20	ounces
Pyro	26	grains
G.—Distilled water	2	ounces
Silver nitrate	50	grains

H.—Clearing.

1 drachm of potassium permanganate dissolved in 80 ounces of water.

I.—Fixing.

Hypo	6	ounces
Potassium metabisulphite	80	grains
Water	40	ounces

J.—Varnishing.

Pure benzol	5	ounces
Gum dammar	1	ounce

The two solutions C and H are so much alike in appearance that it is a wise precaution to keep them in two bottles of totally distinct shape. Little harm might follow the application of H in mistake for C, but if the opposite error were made the picture would be spoilt before anything could be done. The sulphuric acid should be added after the permanganate has dissolved; and in the same way, in making up F, the citric acid should be dissolved before adding the pyro.

The developer as applied to the plate is made by taking half an ounce each of A and B and five ounces of water. Plenty should be used—this quantity is none too much for a plate 13 by 18—as the operation is done, practically, in the dark. The water should be mixed with B, and A should not be added until a moment before use, as the solution discolors with extreme rapidity. For intensification, half an ounce of G is added to five ounces of F, and in this case also the mixture should not be made until just as the solution is wanted.

The varnish is the most messy solution to prepare, and, if possible, therefore, it should be bought ready made. A word of caution may be given as to its use. The solvent benzine gives off a most inflammable vapor, and the varnishing should not be done, therefore, in any room with a naked light. If the varnish is to be made, and it presents no difficulty, the dammar should be crushed by hammering or rolling it while it is wrapped up in paper. It will dissolve in the benzine almost at once, but as commercial dammar is not very clean the solution will be dirty. It may be filtered through a plug of cotton-wool, pushed into the end of a paper cone, made as grocers wrap sugar, and pinned. After filtering it will still be cloudy, but may be used in this condition, or, better still, put on one side where it will be quite undisturbed for a week. At the end of that time, the upper part of the liquid will be water white, and may be carefully decanted from the rest.

A correspondent asks us, in publishing the formulæ for the plates, to add a few words as to the keeping properties of the different solutions. We may say that, except in the case of D (the amidol developer), they all keep fairly well, and some, the permanganate baths, for example, would keep quite indefinitely. The pyro and citric acid (F) would go off in time, no doubt, but some which we made up more than a month ago (with crystallized pyro) is still in good working order and only faintly tinged with yellow. A and B keep very well, G and H quite indefinitely.

THE DEVELOPMENT OF ARMORED WAR VESSELS.—VI.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

Continued from Supplement No. 1656, page 206.

RAMS.

THERE were fitted to the galleys of the ancients ram bows, that were used with good effect in naval engagements with their enemies; so that a beak on a war vessel is as old as the ship. When the naval vessel began to be propelled by sails, then the ram went out of use, for during a combat between sailing vessels there was no desire to bring the opposing vessels in contact with one another, except for the purpose of boarding the vessel for capture. With the use of steam for propulsion came larger vessels, and less dependence upon sail-power for propulsion.

The steam ram is first brought to our notice in this country in rather a crude form, through the presentation of a memorial to Congress by Capt. James Barron, U. S. N., in 1834, of his invention of a "prow ship" for the defense of bays, rivers, and harbors, which was favorably reported on by the Naval Committee of the House of Representatives February 4, 1835; but this seems to have been the last official action taken in the matter. The committee in presenting their report go into the subject very much in detail, but the only reference to the ram itself is contained in these words. After describing the structure as being a combination of three vessels, the center vessel to contain the motive power, the battery, and the crew, and the whole to be driven by side wheels fitted to this center vessel, go on to say of the ram: "It is proposed that this ship shall strike or impinge with an iron-bound pyramidal prow extending in solid thickness in its whole length, and in the mass of the three vessels, fifty feet at least, which no concussion could in the least impair. From its pyramidal form it will enlarge the aperture broken in the ship's side the more it penetrates; and in backing from the wreck the prow will be at once disengaged the moment the pressure forward is withdrawn by the reversed action of the water wheels." The only interest that is attached to this vessel as proposed is that the ram is for the first time, though impractical as here designed, recognized as a weapon of war in a steam vessel. The design of the vessel is hardly worth considering as a whole.

That the designer of the Stevens armored steam battery had an idea, at first at least, to fit the vessel for ramming purposes, there is every evidence. It is found by reference to the letter of August 13, 1841, on another page, in the two last paragraphs, where the writers say: "We propose to construct a vessel whose principal means of offense should consist in her great strength and capability of resisting without injury a shock that would sink her opponent. That no two steam vessels of war at the present day could come together at a speed of say six or seven miles an hour without sinking one or both, is in our opinion certain. What, then, must be the effect of coming in contact with a vessel, safe from shock herself, at double that speed? Instant and immediate destruction." It will be noted that the *principal* means of offense was to be her great strength for ramming combined with high speed. By referring to the letter of Robert L. Stevens of January 25, 1842, on the proposed steam battery, it is found he makes no special reference to the vessel being constructed for the purpose of ramming or sinking an opponent's vessel by forcible contact, other than the high speed to be attained; but more reliance was to be placed upon the offensive power of the shell guns and the resistance of iron armor.

About the time of the "Monitor" and "Merrimac" naval engagement in 1862 there was a letter written to one of the New York papers which stated that a letter had been written about this period of the Stevens battery, on this subject of a steam ram, to the Navy Department. If such a paper can be found in the files of the Navy Department, it will undoubtedly furnish further evidence of the early reference, in this country, of the proposal for a naval vessel to be fitted for the purpose of a ram. The writer was no mere theorist, but was a member of the firm at the time of R. & G. L. Schuyler, of New York, who were largely interested in steam navigation on the Hudson River and on Long Island Sound, and in 1841 had built for the Russian government one of the largest steam frigates of that day, named "Kamschatka," of about 2,000 tons, by W. H. Brown, of New York, having a pair of Lighthall's half-beam engines, at a cost of $600,000 when ready for sea. At a later period the writer of this letter was one of the original owners of the well-known yacht "America," that received the Queen's cup in the yacht race in Great Britain. The letter referred to is as follows:

"At your request I send you the substance of my remarks to you this morning upon the subject of shot-proof vessels. The affair at Hampton Roads proves conclusively that a vessel can be so thoroughly protected against shot that she can receive the broadside of a frigate without injury when approaching alongside; and also that two such vessels similarly protected can fight each other for five hours, as did the 'Monitor' and 'Merrimac,' armed with guns of the heaviest caliber, without injury to ship or men, probably until their ammunition was exhausted.

"A shot-proof vessel like the 'Merrimac' or the 'Monitor' thus becomes the most formidable mode of attack upon the water, passing unharmed the largest forts, and attacking without injury ships of any size. How then are they to be repulsed? Not by a useless expenditure of ammunition at long or short range, for in their powers of resistance they have outstripped the improvements in cannon, and for the present gunpowder is useless as a means of destroying them.

"Many years ago I corresponded with the then Secretary of the Navy, Mr. Upshur, upon the changes which would take place in naval warfare in consequence of the introduction of steam. My object was to call attention to the fact that if steamers were built of very great speed, with their bows made shot-proof with iron plates, so that in approaching an enemy's ship the

could resist his fire, more execution could be done by running down vessels than by the use of cannon. It is generally supposed that in such a collision the risk of injury to both parties is equal; but a moment's reflection will show that a body moving with a great velocity, striking one at rest or moving very slowly, destroys it, without injury to itself. A river steamer, that would not live one-half an hour at sea in half a gale of wind, moving at a rate of 16 or 18 miles an hour would cut down the strongest ship of the line, and sink her without injury to herself. I was enabled to furnish Mr. Upshur with many proofs of the fact well known to boatmen in our waters. The most remarkable instance was that of the North River steamboat 'Empire.' This vessel approaching New York in a fog got within the line of a long pier built out in the river at the upper end of the city. She struck the solid part of the dock bow on, and penetrated through string piece, filling, etc., 27 feet, and backed out without injury to herself. The measurement and size of timber in the pier were forwarded by me to Washington, with a drawing, and are probably yet to be found in the Navy Department.

"If, then, the 'Merrimac' should attempt to put to sea, let this mode of attacking her be adopted, and she can be easily destroyed.

"As the suggestions to the Secretary of the Navy for plating with iron the bows of all steamers were never acted upon, I cannot say whether such a steamer as the 'Minnesota,' for instance, could stand the fire of the 'Merrimac's' guns while coming up with her at full speed. But if she can, the result would be the destruction of that vessel. Even if the 'Merrimac's' fire should cause the pursuing steamer to sink after having made the collision, the sacrifice should be made rather than permit her to go to sea. Any other steamer of great speed, with a small crew and no guns, would answer as well as a war steamer for this purpose, if she can be protected sufficiently from the effect of the 'Merrimac's' guns during the short time required for her to come up to full speed.

(Signed) "George L. Schuyler."

A. P. Upshur was appointed Secretary of the Navy by President Tyler in 1841 and transferred to the State Department in May, 1843, on the resignation of Daniel Webster. He was killed by the explosion of the wrought-iron gun on the naval steamer "Princeton" on February 28, 1844. George L. Schuyler's correspondence with Mr. Upshur as Secretary of the Navy must have been prior to 1843, and that relating to the steamboat "Empire" subsequent to April 25, 1845, as found on another page.

The Navy Department has recently made search for "letters alleged to have been written to the Secretary of the Navy between 1841 and 1843, and in 1845 or 1846, by George L. Schuyler, of New York, relative to the introduction of steam in the navy, and of the value of vessels having high speed, their bows protected with iron plates, and fitted for the purpose of ramming an opposing vessel; you are informed that after a careful search of the Department's records from the year 1841 to 1846, both inclusive, it is unable to find any communication from George L. Schuyler in which the protection of ships' bows with iron plates or fitting for the purpose of ramming an opposing vessel is mentioned." It may be that these letters were considered of a personal character and did not enter into the department's papers.

That there was such an opinion held at this period, and that it was entertained in official circles, is found by reference to the report of the Naval Committee of the House of Representatives on June 12, 1846, on the construction of iron war steamers, where R. & G. L. Schuyler, who were one of several bidders, offered to build such a vessel, "to be secure from shot and to have a speed of at least 15 miles an hour." In this same report the committee say: "Much has been said of late respecting the possibility of sinking a line-of-battle ship with a heavy steamer going at the rate of 14 or 15 miles an hour, and cutting her athwartships. Your committee have deemed it proper to make some inquiries on this subject, and without venturing an opinion will only say that the facts stated in the letter of Mr. George L. Schuyler, and illustrated on the diagram attached to it, seem to sustain the idea that the result might be accomplished." The diagram mentioned by the committee is more than probable a sketch of the dock, with measurements of the timber, break, etc., that the steamboat "Empire" ran into, and referred to in George L. Schuyler's letter.

It does not seem that the ram, as an engine of naval warfare, received any further attention until Charles Ellet, Jr., a civil engineer of Richmond, Va., at the time, wrote the Secretary of the Navy in February, 1855, on "Steam Battering Rams," in which he said in part: "My plan is to convert a steamer into a battering ram, and to enable her to fight, not with her guns, but with her momentum. In short, I propose to strengthen the steamer throughout in the most substantial manner, so that she may run head on into the enemy, burst in his ribs, or drive a hole into his hull below the waterline. A hole only two feet square and four feet under water will sink an ordinary frigate in sixteen minutes. . . . For harbor defense, however much we may continue to build and arm forts and batteries, I think we should not neglect also to build floating batteries, rams, great steamers as near shot and shell proof as they can be made, with a strength of hull, speed, and power that will enable them to crush the side of a man-of-war by simple collision. To my understanding, the efficacy of the plan which I recommend is self-evident. And I hold myself ready to carry it out, in all its details, whenever the day arrives that the United States is about to become engaged in a naval contest. . . . The practical conclusion to be drawn from these facts is apparent. If vessels built for ordinary common civil purposes, and propelled either by steam or sail, invariably sink the vessel they strike with their bow when running with any considerable velocity, while themselves receiving but little injury from the collision, it follows of necessity, and *a fortiori*, that a steamer expressly designed for such conflict, well fortified at the bow, strongly built throughout, divided longitudinally and centrally by a solid partition reaching from keelson to deck, and from stem to stern, and transversely by other partitions, separating the hull into six or eight watertight compartments; and horizontally by one or more partitions or floors, of which one shall be below the waterline when light, I say it follows of necessity that such a vessel, skillfully framed and properly fastened, may be driven at high speed against any ship of ordinary construction in the certainty that the ship struck will go down, and the battering ship float."

His advocating the subdivision of the hull of a vessel in such a thorough manner at that early day, when such vessels were *almost* unknown in this country, there being very few merchant vessels in the United States with watertight bulkheads, shows him to have been in the front rank of progress at the time. He laid down his life in carrying out his theory of a steam battering ram in its practical application during an engagement in the civil war. He was thought to be a "dreamer" or a crank on the subject of steam rams at this time. The Secretary of the Navy replied to his letter on March 21, 1855, in part as follows: "The suggestion to convert steamers into battering rams, and by momentum make them a means of sinking an enemy's ship, was proposed as long ago as 1832, and has been renewed many times since by various officers of the navy. No practical test has been undertaken; but with the necessary speed, strength, and weight, a large steamer on the plan proposed by you would introduce an entire change in naval warfare." It is hardly necessary at this day to say that the change in naval warfare came sooner than was anticipated. This letter shows that the advisers of the Navy Department at the time were of much influence and power in its counsels. At this time France and Great Britain were building the steam armored floating batteries for the Crimean war.

A few years passed on, and no advance or progress was made in our naval vessels until the opening of the civil war, when many designs for iron war vessels were offered to the government at Washington. It is at this time that the design of the Stevens battery was first brought to public notice. The plans as submitted to the Naval Board in 1861 for the completion of the vessel showed a ram bow, similar to many naval vessels of a later date; but there is no reference to a ram bow in the report of the Naval Board who examined the vessel, nor is there any such reference in the reply of Edwin A. Stevens to the report of the Naval Board. If the vessel was structurally weak for sea duty, it was certainly more so for service as a ram. That the vessel did not have a ram bow in 1861, nor even later, is very evident. An examination of the plans of the vessel when offered for sale in 1874 shows a bow similar to one of our merchant vessels; but the first reference to a ram for the vessel is found in the description given at that time of the changes that had been made in the vessel. "It was concluded to introduce an inner skin, transverse water-tight bulkheads, water-tight coal bunkers, to build new engines, and to prepare the ship for transformation either into an ironclad of the 'Monitor' type, having very high speed, carrying a powerful armament within a turret of extraordinary thickness, and capable of acting efficiently as a steam ram, or into a broadside ironclad. The bow of the vessel was modified accordingly, and was considerably strengthened by means of water-tight transverse and longitudinal bulkheads, and breast hooks. . . . The strength of general structure, the peculiar construction of the bow, and the great power of the vessel make it a very effective steam ram. . . . The handiness of the vessel . . . gives a facility in maneuvering which is a most essential advantage in a ram." The bow still retained the merchant vessel form.

What gave our naval architects, as well as Col. Ellet, the first practical demonstration of the value of the principles of high speed and strength of a vessel to destroy an enemy's vessel by forcible contact was that of the occasion of a light-built river steamboat running into a solid-built pier in the city of New York, with comparative slight injury to the vessel. It was in the early morning of April 25, 1845, that the steamboat "Empire," of Troy, of the New York and Troy line, was coming down the Hudson River, and when opposite the upper part of New York city, during a fog on the river, ran into the end pier of the new dock at 19th Street, about thirty feet from the outer end, and cut her way through the timbers of the dock and stone filling of the cribwork. This pier of cribwork was 40 feet square. There were three of these piers under this dock, the latter being 265 feet long from the bulkhead and 40 feet wide, and lacked the heavy plank facing to be completed. The sills, string pieces, and heavy timbers of the dock were of rough timber 18 inches square, and the "Empire" cut through these with a "tremendous crash," cutting them short off, as a light piece of wood would be cut with a sharp tool. These timbers were afterward found to be sound and free from defects, excepting those caused by the steamboat collision. The "Empire" plowed her way through the solid rock filling of the pier some 27 feet before stopping. The opening by measurement at the time showed the 18 inches of timber, then solid stone filling of 8½ feet thick, and then through earth and rubbish 17 feet further, making a total opening of 27 feet long, and 17 feet deep at the deepest point. The stem piece of the vessel was carried away, several of the forward ends of the planking on either side were badly shattered, and a few of the frames started. Both of the forward ends of the hog frames of the vessel were broken.

When the type of vessel is taken into consideration, being 307 feet long, 30 feet 6 inches beam, or about 1 to 10, and built with a flat floor that ran well out to the fore body of the vessel, to make her as light draft as possible; coming down the river with a strong tide, that was on the last hour of the ebb; and when the filling of the pier was the most exposed, it is certainly remarkable that the vessel was not more seriously injured; but as it was, the hog frames being partially broken and otherwise badly strained, showed the vessel received at the time a severe shock throughout the whole structure. It was only that the vessel was traveling at a high velocity when she struck the pier that saved her from being badly crushed, for it must be remembered she was not a heavy-built vessel, nor was she a shell. She was undoubtedly moving at the time of the impact at not less than 12 miles an hour. She had been racing all night from Albany with an opposition boat, and the time made from Albany to the pier when struck showed an average of 18 miles an hour. This was no accident.

This ramming incident was variously commented on at the time by those in the more progressive marine circles, and it caused much speculation and thought on the subject of steam vessels being brought into forcible contact at a high speed. It was a subject of much local comment for some time how the vessel escaped destruction.

There was one other incident of the same nature that occurred some years later, and these complete the list of wooden-hull river steamboats running into stone crib piers with slight injury to the vessel, in the United States. The "Thomas Powell" was running between New York and Catskill on the Hudson River as a night boat, and on July 23, 1868, when about four miles from her berth at the former city, ran into a dock at the foot of 59th Street, North River, and met with comparatively slight damage when considering the age of the vessel. It seems that the vessel ran into a thick fog during the night on her trip down the river. The pilot on watch in the early morning had but a limited experience on steamboats, though he had seen several years' service on the river. He was feeling his way down the river in the fog, and up to four o'clock, when the vessel ran into the dock, had been making a speed of about 12 miles an hour. The vessel struck the string piece of the dock with a fearful crash, and this was the first warning they had of the impending danger. Some idea of the velocity of the vessel when striking the dock may be formed, when stating that she tore diagonally through the superstructure of the dock between two piers of stone cribwork, and forced her way through until the paddle wheels struck the cribwork, and she did not bring up or stop her progress until about one-half of her length was laid on the pier, and the ends of the vessel hanging over the sides of the cribwork. Her port water wheel was badly damaged, its shaft forced two feet aft from its proper position, with the crank pin and main pillow block broken. There were one or two planks started on the port side, but not of sufficient damage to take her out on the drydock. The vessel was relieved from her dangerous situation at the next flood tide. The dock had been damaged by ice two years before this occurrence, and was partly overflowed at high water. The tidal conditions at New York this morning were low water at 5 A. M., so the vessel was running with a favorable ebb tide, and it was on the last hour of that tide when she struck the pier. This vessel was 231 feet long originally, and it is believed she was lengthened a few feet when staterooms were added, drew about six feet of water,

and was twenty-two years old at the time. Her main shaft was located about 95 feet aft of the stem of the vessel. Taking into consideration the age of the vessel, and the manner of her striking the cribwork at such an angle as to bring all the strain on the port side of the vessel, it is a wonder that she was not irreparably damaged. It proved that she was still a sound and strong river vessel, even with her years of service. She was employed on the river until 1881, when retired after thirty-five years of service. There were material differences between these two cases that no doubt affected the result. The "Empire" was a new vessel, and ran into a dock that was just about completed. The "Thomas Powell" was then twenty-two years old, although in as good condition as any wooden vessel of her age; and ran into a dock that had been built for several years, and was then in a partly dismantled condition. What the result would have been had the vessel struck a more substantial pier under similar conditions is very problematical.

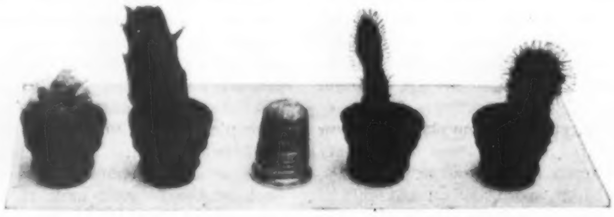
(To be continued.)

THE CULT OF THE CACTUS.*

THE POSSIBILITIES OF A LITTLE-UNDERSTOOD PLANT.

BY S. LEONARD BASTIN.

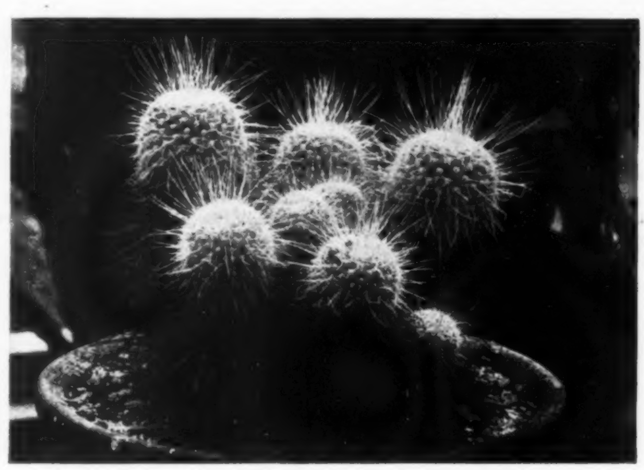
After all it must be admitted that Cacti together with the allied succulents are plants of more than ordinary interest. Always quaint in their manner of growth, and exhibiting an amazing range of form in the different varieties, many of the Cacti in addition are productive of the most lovely flowers—blossoms which in form, color, and fragrance often surpass anything that could be imagined. Over and above all, almost without exception, Cacti are of simple culture, flourishing under conditions which any gardener can supply. A cool glass-house, which in winter is heated to a moderate degree, will meet the needs of these plants in northern latitudes, while in more favored climes they will succeed out in the open.



DIMINUTIVE CACTI. THE SMALLEST POTTED PLANTS IN THE WORLD.

It is generally supposed that Cacti, as a whole, flower only at the rarest possible intervals. This is a great mistake, for as a matter of fact many of the varieties blossom annually, and even twice in the year. Of all the groups, the Phyllocacti flower more freely than any others. These plants are distinguished by their flattened stems, and as all the species have received a good deal of attention from the florist within recent years there are many splendid varieties now obtainable. The thanks of all Cactus lovers are due to the late Mr. John Nicolai, a German enthusiast who made it his special care to improve the Phyllocacti. Some idea of this specialist's interest in the matter may be gathered from the fact that when he died recently he left behind him about twelve thousand specimens of this particular group. The colors of the blooms of the Phyllocacti range through all shades of red and yellow down to the purest white, while the flowers are particularly perfect in form.

The Sea Urchin Cacti or Echinocacti are remarkable chiefly on account of their strange shape. Of course in the different members of the group there is a great diversity, but the general form is somewhat spherical, the plant as a rule being armed with dense masses of prickles. Many Echinocacti bear gaily colored flowers, but these are scarcely so finely formed as is the case in other groups, as for instance the Epiphyllums. All the kinds of this class are exceedingly floriferous, and bear great masses of bloom, each blossom of which is most elegant in design.



A FINE ECHINOCACTUS.

Numbered among the group known as Cereus are many interesting species. First and foremost must be mentioned the giant of the whole family *C. giganteus*, a native of the Mexican deserts. As this plant under natural conditions will grow to the height of eighty or ninety feet it may be imagined that really large examples are out of the question in glass-houses. The Old Man (*C. senilis*) is a species always worth growing, as the plant itself is an object of great beauty at all times. A fine example of this variety is thickly covered with silken hair which strongly resembles the white locks of an old man. The most interesting of all the kinds which go to make up the genus Cereus is the "Queen of the Night" (*C. grandiflorus*), a plant which in habit is one of the most curious in the world. This species bears large white blossoms, which are deliciously fragrant, and the strange part about these flowers is that they do not expand until between eight and ten o'clock in the evening, while they are quite over by three the next morning. Thus each particular bloom does not at the most last more than six hours, and is not to be seen except in the dusk or by artificial light.

The propagation of Cacti from seed is one of those things which require an immense amount of patience. Most of these plants are naturally slow growers and the time needful to produce a flowering-sized plant from seed would in many species be as much as the span of a man's life. Most people will prefer to adopt the method of raising fresh plants from cuttings, and this is a very simple matter indeed. Practically any healthy portion of a Cactus will grow, and at almost any time of the year, if it be placed in some sandy soil and kept in a moist condition. Fairly large plants can be grown in a short time. The writer produced a splendid *Phyllocactus albus*, which blossomed magnificently in three years, which may seem a long time, but is a short period in the life of a Cactus.

A charming hobby, and one which is largely followed by German ladies, is the collection of miniature Cacti. As has been mentioned any part of a Cactus will take root, and this habit has been turned to account. Very small pieces of the succulent stem are rooted and then placed in tiny pots, scarcely so large as a thimble. With a little care not to over-water, these dainty plants will not increase rapidly in size, and yet will remain in a healthy condition, although they will not flower.

* From American Homes and Gardens. Published by Munn & Co.

A HUGE SPECIMEN.

A GIANT "OLD MAN" CACTUS.

THE CULT OF THE CACTUS.

Details have just been completed for the task of unwatering Union Island, located in Sacramento County, California. This entire island was completely inundated last March by the very high freshets that prevailed; the floods breaking over the dyke. The island contains about 13,000 acres, on which the water now stands to a depth of from 5 to 9 feet. All this great quantity of water is to be pumped out, the levee repaired, and the land be again put in cultivation. Six large steam pumps, each with a capacity of 100,000 gallons an hour, are being installed, and a canal system will be used to carry off the surplus water. This will prove an enormous pumping undertaking, and will require fully three months to complete. It is estimated that the total cost will reach about $70,000, but the land is considered far too rich to permit it to lie under water. The river's sediment will add greatly to the fertility of the soil.

THE USE OF SOIL SURVEYS.*

IMPORTANCE OF ACCURATELY STUDYING THE SOIL.

BY J. A. BONSTEEL.

The soil of the United States constitutes the one great inexhaustible natural resource of the country; from it spring not only the food and raiment of the people, but nearly one-half (42 per cent) of the materials used in manufacture, and a majority of the materials exchanged in commerce. From the soil, in the present generation, the farmers of the United States have won a living for themselves and for their countrymen, and in addition have furnished the commodities whose sale and exchange have much reduced the dependence of this country upon the capital of foreign nations.

SMALL PROPORTION OF LAND UNDER TILLAGE.

The agricultural domain of the United States (exclusive of the outlying possessions) in 1900 comprised 5,739,657 farms, aggregating 841,201,546 acres. Of this area almost exactly one-half is improved land and the remainder consists of woodlots, swamps, and land that has never been plowed or cropped. Although this is a great total, less than one-half of the whole land area has been turned into farms, and less than one-fifth is actually improved. Even upon this showing the farm lands of the United States comprise seven times the farm-land area of France, with 39 million people; eight times the farm-land area of Germany, with 60 million people; and thirty-one times the farm-land area of England and Wales, with 34 million people. The American farms now existing could be made to produce enough to feed many times the country's present population were the best and most intensive agricultural methods of European countries applied, and still have a surplus for export.

A TYPICAL CACTUS CUTTING.

It is to the full development of these vast but dormant resources that the soil-survey work is devoted.

SOIL RESOURCES MAY BE GREATLY INCREASED.

The soil itself is not a fixed and generally decreasing source of income, as are many of the other natural resources of the country. The wealth of the soil may not properly be compared with a fixed bank account upon which drafts in the form of crops are continuously drawn with the ultimate result of the complete exhaustion of the capital involved. The soil is more nearly comparable with an invested fund whose annual interest is paid in the form of crops, and which, under proper management, may be continually increased from its annual earnings. The forces of nature which have produced soils have not ceased to act, and through their steady, continued operations they are capable of maintaining and renewing the producing power of this great natural resource when they are properly directed and assisted by the husbandman. In this respect soils, as a natural resource, differ most materially from mines. The mine of metal or of mineral fuel constitutes a resource whose extent may be ascertained and whose total content may be measured. It is possible under certain conditions for skillful engineers to estimate with considerable exactness the total amount of material which may be removed from a mine, and the length of time which it will continue to yield. With the soil this is not possible. Even where surface soils are bodily removed and useless subsoils are exposed, these, if only left to nature, may in time be brought to useful productivity; when nature is properly assisted the process becomes rapid. When through mismanagement the crop-producing power of a soil is impaired, a simple change in crop rotation or in the mechanical handling of the soil is often sufficient to make its continued cultivation possible and profitable. Thus the soil, under businesslike and scientific management, is capable of yielding not only annual but annually increasing profits. While bad management, neglect, or avarice may cause a temporary check in the producing capacity of the individual field, history shows and statistics prove that, in all civilized countries, through all historic times, the soils of the world have responded with increased crops to increasingly intensive culture for the support of growing populations. It is only within brief periods of time and over limited areas that improvidence or neglect has been able to cause decreased returns from the soil.

The time has not yet arrived when even the present known resources of American soils are fully called upon to feed the people of our own nation. No such intensity of cultivation is demanded as in Germany, where the average farm comprises 19 acres, or in France, where it is 34 acres, nor even as in England and Wales, where it is 63.4 acres. In the United States land is still so abundant that the average farm contains 146.2 acres, and less than half of it is improved. The time may some day come, and doubtless will—it may be when there are 300 millions of Americans instead of 85 millions—when more land will be needed for farms. Much sooner will come a time when the farm land now in use must be handled more intensively and more effectively and each acre must be made to produce to its maximum capacity the crops for which it is best fitted.

STUDY OF LARGE PROBLEMS.

It is partly in anticipation of that time that the soil survey is examining into the total soil resources of the country and investigating the broad problems of the relationship of soil to crop, which must be solved before American soils and American farmers can do their best, the one for the other. In crop production, even under ordinary farm methods, there are two groups of influences which control the selection of appropriate crops—the planning of crop rotations and the adoption of correct systems of farming. These are the influences of the climate and the soil. Neither may be neglected by any man who hopes for complete success, and the due and relative importance of each must be ascertained.

A FINE COLLECTION OF CACTI INCLUDING A SPECIMEN OF THE GIANT CACTUS.

EXTENT OF SURVEYS ALREADY MADE.

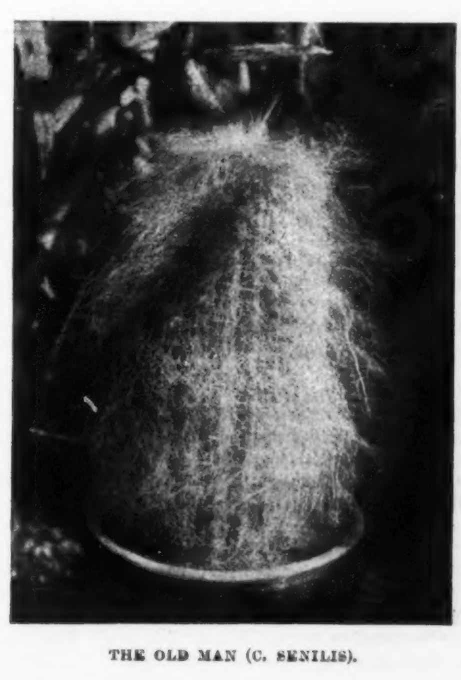
The work of making soil surveys was begun in 1899, and by June 30, 1906, an aggregate area of 118,686 square miles, or 75,959,865 acres, had been mapped. This comprises something less than one-tenth of the area actually in farms and about one twenty-fifth of the entire area of the United States. These surveys have been made in 43 States and 4 Territories. They have been so distributed as to constitute numerous studies of each important geographical and agricultural district.

SOIL TYPES, SERIES, AND PROVINCES.

The work of the soil survey is based upon the principle that there are differences among soils which so affect plants that not all soils are equally suited to

* From the Year Book of the Department of Agriculture.

WEST INDIAN TURK'S CAP CACTUS.



THE OLD MAN (C. SENILIS).

THE CULT OF THE CACTUS.

the production of all crops. This work, therefore, comprises a study of both the character of these soil differences and the effects which they produce in the growing of farm crops.

In the field work of the soil survey the soils are studied to determine their texture, or the relative amounts of coarse or fine particles of which they consist; their structure, or the relationship of these particles one to the others; their organic matter content, both quantity and distribution; their internal natural drainage, and their topographic relief. These factors operating together determine the character of the home which plants are to find in the soil. All masses or areas of soil which are found to be closely similar in all of these respects are said to belong to the same soil type. Under similar climatic surroundings the type is capable of producing similar kinds of crops, and under the same conditions of farm management and of farm efficiency they may be expected to produce practically equivalent amounts of crops.

It has also been found that several soil types in a given region may differ only in their texture, being identical or similar in all other respects. Such a group of soils is called a series. Again, several series have been found to be derived from the same classes of material by similar processes and to exist in a region having similar climatic features in the broadest sense. Such a region constitutes a soil province.

EXTENT OF SOIL TYPES.

The soil survey recognizes at present 13 great soil provinces, 58 soil series, and 461 soil types. Of these types some 130 are more or less local in character, while the remainder are of widespread occurrence within their respective provinces. For example, the Norfolk sand is a warm, porous soil of the Atlantic and Gulf Coastal Plain Province, suited to the production of truck crops. This type has been mapped in 34 different areas, located in 14 States, extending from New England to Texas. The total area covered by this type in the areas mapped amounts to 1,702,000 acres, or 2,660 square miles. Its extent within the total area of these 14 States is many times as great. Throughout the region where it occurs this soil has a definite crop adaptation, and the variety of crops which may be raised successfully upon it is limited by nature.

Similarly the Marshall silt loam has been mapped in 22 areas, located in 9 different States, to an extent of 3,921,000 acres, or 6,126 square miles. It is again safe to say that within these States several times as many acres exist as have been mapped. Seven-eighths of the area of this soil is pre-eminently adapted to corn production, and the remaining one-eighth, while under climatic surroundings unfavorable to corn, is well suited to the production of one or more other crops of equal value.

Although these two types of soil are extreme cases, they are by no means the only valuable soils of wide distribution and well-recognized crop adaptation. Among the other 459 types there are some of which areas as large as the smaller States have already been mapped. There are others of which areas scarcely larger than a single township have so far been encountered and mapped. Whether extensive or limited in area, each presents its own peculiarities and no two could safely be classed together as possessing identical properties and the same utility.

ADAPTATION OF CROPS AND SOILS.

Enough has been said to demonstrate the wide range and the wonderful richness of the soil resources of the country. The other problem of equal importance, possibly the greatest agricultural problem of the nation as a whole, is that of the proper and complete development of these resources along lines which shall give not only increased crop values, but also increasing ability to produce crops upon the part of the soils.

Careful consideration must be given to the fact that at least 461 types of soil possessing distinctive properties are already known to exist. It rests with some one, whether a private individual or a public official, to determine the crop or crops to which each one of these soils is best adapted; to advise the methods of soil management by which each one of these soils may be made to produce a sufficient crop to repay all expenses and to render a profit; to adapt the systems of farm economy through crop rotations, tillage, and fertilization so that these different soils may produce their crops for long periods of time at least without deterioration and, if American farming is to become a science, with actual increase in crop-producing power.

Moreover, it is necessary that the discovery, introduction, and culture of crops adapted to these various types shall follow such lines that the greatest food values as well as the highest commercial values shall be rendered by each soil. It is also a necessity that upon widely extended types such crops shall be grown as are subject to wide demand in the markets of the world. Otherwise the farmers engaged in crop production must face a destructive competition or else portions of the soil type must be neglected or but feebly utilized. One may anticipate the time when all areas of Norfolk sand having suitable climatic conditions and transportation facilities can be made to produce great crops of those vegetables which now constitute winter luxuries for the few. At the present day such widespread production, coupled with a limited demand, would force prices to a point where the returns from the crop would only pay the charges of transportation and of retailing and the producer would be left with neither expenses nor profits paid. Therefore, before such anticipations can be realized, either demand must increase, as it will with increasing population and individual wealth, or transportation costs must diminish, as they also will with the progress of invention and a proper increase in competition.

The soil-survey work thus possesses a dual aspect: (1) It must deal with those problems of crop and soil adaptation which concern the present individuals and generation; and (2) it must accumulate a fund of information in regard to soils which will assist in solving the broad problems of the nation's soil resources, and the utilization of these resources, not only for the support of a growing population, but also for maintaining a favorable balance of trade for the nation.

REPORTS ON ACTUAL USES OF SOILS.

The individual report upon each soil-survey area contains an account of each soil type within the area. It gives a description of the characteristic appearance of the type and summarizes the crop uses to which it is put within the area. The methods of handling the soil are given, and a general statement is also made of the range of crop production. Such a report summarizes the actual uses of the soil within these restricted limits, and it also summarizes the farm practices in the given region. Each report also contains an account of the crops raised in other areas where the same type of soil has been encountered; and suggestions as to new crops, new methods of soil management, and new industries are made as a result of this wider knowledge secured from numerous surveys.

PRESENT USES OF SOIL REPORTS.

From these reports on soil surveys the individual farmer may learn the relationships of the soils upon his own farm, not only to the other soils in the immediate neighborhood, but to soils of the same character in widely separated regions. He may thus observe and study understandingly the methods and results obtained under the most favorable conditions by successful farmers upon these soils. His horizon of observation is enlarged, and he may more surely apply the experience and the observation of others to his own particular needs and conditions. He is able to consider his own farm, not as an isolated property, but in its due relationship to other farms located upon the same soils and in a region of similar climatic surroundings. The single report thus serves the purpose of the individual whose problem is one of a fixed and occupied region.

At the present time, as at all times in the history of the country, there is a large class of persons who for various reasons desire to secure new farms in more or less distant localities for the pursuit of general agriculture or for the production of special crops. Inquiries from such persons always cover certain climatic and soil features, and each desires to secure information which will enable him to compare conditions personally known to himself with those of new localities under consideration. Inquiries of this nature are constantly received at the Department of Agriculture, and wherever possible the information is supplied by the reports and maps covering the areas concerned. No advice to do this or that is communicated; only the information upon which a judgment may be based. The use of soil-survey reports for this purpose is by no means confined to reports upon regions which are sparsely settled or newly opened for agricultural occupation. The constant changes in farm values in all parts of the United States are calling the attention of individual farmers to particular localities in the older States, where possible advantages may be gained from the sale of high-priced lands and the purchase of others which, for the time, are offered at a lower figure. Greater demands have been made during the past few years for soil-survey reports covering areas in the Eastern and Southern States than for those in any other localities. Whatever the cause, the attention of individuals and of investors is strongly shown by this demand.

During the past decade the funds accumulated by large investment companies have increasingly sought a farm-land outlet. The soil-survey reports are regularly requested by many such companies. Some only desire the reports in particular circumscribed regions. Others desire these reports as an unprejudiced basis upon which a judgment of land uses and of farm development in widespread and remote regions may be based. Obviously, the common interest of the entire community is served by these reports of soil facts, just as the individual interests of the persons concerned are safeguarded at the same time.

The use of the soil-survey maps and reports by educational institutions has greatly increased within a few years, accompanying a renewed activity in the study of soils and in the teaching of soil subjects. Not only are the maps and reports used by those institutions directly for the study of soils, but they are also used in studies of crop production, of farm economics, and of the distribution of agricultural products. Non-agricultural colleges and universities are also using these reports in connection with courses in commercial geography. It has thus become necessary to hold such uses in mind in the distribution of the individual soil-survey reports and of the annual report known as Field Operations of the Bureau of Soils.

FUTURE NEED FOR EXACT INFORMATION.

All of these uses of soil maps and of soil-survey reports are immediate and present. They are more or less personal to the individual farmer, investor, or student. They do not constitute the only use nor possibly the greatest use of these surveys. As agriculture, based on the soil as its fundamental resource, is the greatest business of the country at the present time, so it must remain for many generations to come. Agriculture is still a generalized business, although its specialization into horticulture, market gardening, tobacco culture, cotton culture, and other subdivisions has begun. With increasing population, with greater intensity of cultivation, greater demands will continually be made upon the soil and greater precision and skill in the selection and handling of soils for special crops will be required. It will be extravagantly wasteful to allow these developments to occur along the lines of chance and to secure the ultimate ends as the result of haphazard trial or experimentation. The soil and climatic factors which govern plant and crop growth must be understood and appreciated. Whenever through any cause a particularly valuable crop is brought to perfection upon a given soil, the extent and geographic distribution and the climatic environment of that soil must be known in order to insure the successful spread of its culture.

Even at the present day there is continual inquiry as to the soil conditions under which specific crops may be successfully grown, and crops formerly confined to narrow regions are spreading to other localities. The culture of alfalfa, the production of sugar beets, the introduction of new varieties of tobacco or of old varieties into new regions, all illustrate this tendency. Discussions of soils in connection with the great staple crops are usually confined to corn soils, wheat soils, cotton soils, or grass soils. Little attention is paid to the pertinent fact that each of these crops has developed well-marked varieties suited to quite different regions, climates, and soils. It has become necessary to study not tobacco soils, but cigar-wrapper tobacco soils or cigar-filler tobacco soils. This is recognized. The equally important fact that corn and wheat, cotton, rice, and the other great staples should be studied as varieties, adapted to different kinds of soil has not been equally emphasized.

From the study of American soil differences, soil adaptations, and soil resources, and from the long-continued observation, classification, and correlation of soil and crop facts, may be ascertained by the specialist new uses, now unperceived, of each and every acre of agricultural land, so that statistics will no longer report less than one-half of the land of the country apportioned into farms and less than one-fifth actually improved and tilled. From these studies and from the development of laws of soil and plant association it will undoubtedly be possible, at some future day, to increase the number of great staple crops from a scant dozen to several score, each occupying its proper place in the farm economy of the country and each produced under those circumstances of soil and climate best fitted to its growth.

Those other problems, even now appearing in American agriculture, of the rehabilitation of so-called "worn-out" and abandoned farms, of maintaining and even increasing the producing capacity of broad areas, while they are probably economic and farm-management problems to a considerable extent, are only capable of solution after a thorough study of the soil conditions in the field. These problems may not even be outlined without the aid of soil-survey work; much less can they be solved.

The time has come in the agricultural development of the United States when accurate and detailed knowledge of the soil—its character, varieties, capabilities, and adaptations—is of great importance; and as the years go by such knowledge will become more and more important, until ultimately our greatly increased population will need and will be able to utilize fully the diverse capabilities of these 461 different types of soil.

Removing Rust from Jewelers' Tools.—The tools are immersed for a night in a saturated solution of bichloride of tin, which removes all spots. In the morning they are washed in soapy soda water and wiped. Finally, they can be cleaned with pure alcohol and chalk; this last operation not being indispensable.

TERTIARY MAMMALS AND THE DOCTRINE OF EVOLUTION.*

CHANGES IN PALEONTOLOGY SINCE DARWIN'S DAY.

HALF a century ago the exploring expeditions connected with the Smithsonian Institution began to collect fossils from the Tertiary deposits of the western plains. Later the work was followed up by the geological surveys under the auspices of the national government, and by numerous private expeditions under the auspices of universities, scientific associations and individuals. Over those western plains were found to stretch vast continental deposits, certainly not all of lacustrine origin, as at first reported, but in part piedmont alluvial formations, in part eolian deposits, and, in limited areas, deposits of volcanic dust. These continental deposits of the western plains yielded in unparalleled richness mammalian fossils, which have been studied by Leidy, Marsh, Cope, Osborn, Scott, Wortman, and others. No other single series of discoveries has been so potent in changing the bearings of paleontology upon the doctrine of evolution.

In Darwin's two chapters on geology in the "Origin of Species," he marshaled with great skill the geological facts then known which appeared favorable to evolution. Yet he recognized in the facts of paleontology "perhaps the most obvious and serious objection which can be urged against my theory." He cited a long list of recognized authorities in geology and paleontology, still living or recently dead at the time of the publication of his first edition, who were believers in the immutability of species—Cuvier, Agassiz, Barrande, Pictet, Falconer, Forbes, Lyell, Murchison, Sedgwick. Of these Lyell alone lived to become a convert to evolution.

Of course the objection which Darwin felt so strongly himself, and which seemed conclusive to so many paleontologists at the time, was the absence of gradation between different forms. The theory of evolution, and especially the strictly Darwinian form of that theory, requires fine gradation between species—not indeed between different species now existing, but between existing species and species now extinct, and between fossil species of successive periods. In general, such gradations do not appear. Fossil species are about as sharply defined as recent ones; and whole groups of species—orders, classes, sub-kingdoms—have appeared without recognizable ancestry. Darwin's answer to this objection was given in the phrase now become classical, "the imperfection of the geological record."

In the half-century since the publication of Darwin's first edition, the attitude of paleontologists has completely changed. Not only is it true at present that paleontologists are substantially unanimous in accepting the doctrine of evolution; but it has come to be generally believed that the very science which afforded a half-century ago the strongest objection to evolution now affords its strongest support. This change is in large part due to the discoveries which have so shattered the objection that once appeared so strong. Innumerable links then missing have been brought to light. Intermediate forms between orders and classes formerly supposed to be widely separated from each other have been discovered in great abundance. Numerous series of genera may be traced through successive geological periods, exhibiting a gradually progressive change which almost irresistibly suggests to the mind the belief that the series are truly genetic. The fossils of our western plains have afforded a goodly share of the most important of these new evidences of evolution.

When the first edition of the "Origin of Species" was published, the classes of birds and reptiles seemed to stand widely asunder. But in the very next year (1860) an odd feather of Archæapteryx was discovered, and a year later the skeleton now preserved in the British Museum. But Archæapteryx was a solitary representative of the birds of markedly reptilian character until the discovery of Ichthyornis and Hesperornis in the Cretaceous of Kansas, of which preliminary descriptions were published by Marsh in 1872. Both these remarkable types show reptilian affinities, in the possession of teeth, in the structure of the skull (though unhappily the palatal region is but imperfectly known), and in the pelvis; and Ichthyornis very notably in its slightly biconcave vertebræ, contrasting strongly with the saddle-shaped articulating surfaces of the vertebræ of modern birds. However strongly these genera suggest the idea of an evolutionary connection between reptiles and birds, their own place in the evolutionary series is not easy to determine. Ichthyornis may be in or near the direct line of descent from Archæapteryx to some such generalized dromæognathous type as is represented by those curious living fossils, the Crypturi, from which divergent lines of evolution may have led, on the one hand, to the ostriches and other flightless Dromæognathæ, and, on the other hand, to the Carinatæ. Hesperornis, a degenerate and in some ways highly specialized form, stands certainly at the end of a side branch, and has left no descendants.

But the discoveries of most evolutionary significance, as already intimated, have been among the Tertiary mammals. A number of series have been traced, leading from generalized types in the Eocene, through forms of gradually increasing specialization, to genera which still survive. The first of these genetic series to be brought to notice was the genealogy of the horse, as traced by Marsh in 1874. Marsh's views were adopted by Huxley in his brilliant "American Lectures," and thereby gained a larger share of public attention than they would otherwise have received. Probably no single fact or group of facts brought to light since the appearance of the "Origin of Species" has been so influential in bringing the theory of evolution into general acceptance. The genealogy of the horse has been corrected in detail and completed by later investigations. The line of descent may now be traced through Hyracotherium and Eohippus of lower Eocene, Protorohippus and Orohippus of middle Eocene, Epihippus of upper Eocene, Mesohippus of Oligocene, Anchitherium of lower Miocene, Parahippus, Protohippus, and Pliohippus of middle and upper Miocene, to Equus of Pliocene and Quaternary; while side branches lead to Hipparion, Hippidium, and other forms which have died without issue.

A similar series, though with not quite so fine gradations, reveals the genealogy of the camel. From the Eocene Protylopus this line is traced, through Oligocene Poebrotherium, to Pliocene Procamelus, whence one branch leads to Camelus, and the other to the South American Auchenia. It is indeed remarkable that the characteristically old-world types, Equus and Camelus, should have been evolved in North America and have become extinct in this their original home. Another series, beginning in the lower Eocene Systemodon, ends in the modern tapirs.

In like manner, among the very primitive carnivores which have been classified as the order Creodonta, the ancestors respectively of the dog and the cat have been recognized in the Eocene genera Vulpavus and Palæonictis.

Of extraordinary interest in an evolutionary point of view is the most primitive Tertiary fauna from the Puerco beds discovered by Cope in 1880. In that fauna is found the culmination of the Multituberculata, which made their first appearance in Triassic time, and whose teeth reveal their close relation to the Monotremata. But, with those survivals from Mesozoic time, appear generalized and primitive forms of placental mammals, wherein may be traced the ancestry of mammalian groups of later Tertiary and recent time. Hemiganus and Psittacotherium may be recognized as the ancestors of the Edentata. And, among the most primitive and generalized ungulates, the Phenacodontidæ, Protogonodon has been recognized as possibly the ancestor of the Artiodactyla, and Euprotogonia with more probability as the ancestor of the Perissodactyla.

But, however numerous are the gradational forms which have been brought to light, Darwin's principle of the imperfection of the geological record is in no wise superseded. It still remains true that the theory of evolution must stand or fall according to our judgment of the adequacy of that principle of Darwin. If the fossils accessible to observation and collected in our museums afford an approximately complete representation of the life that has existed in past ages, there is certainly no standing ground for any theory of evolution. But, while we have seen numerous chasms bridged by series of gradational forms, we have also come to a fuller appreciation of the significance of Darwin's principle of the imperfection of the geological record.

In the conclusion of Darwin's chapter on the subject, he used a striking illustration: "I look at the natural geological record as a history of the world imperfectly kept and written in a changing dialect. Of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines." In the light of our present knowledge of geological history, we are able to see that even this striking illustration fails to do full justice to the subject. The imperfection of the record consists not merely in the fact that some of the chapters are missing. It appears most strongly when we inquire just what chapters are missing. In the conception of continental history to which I have already referred, we have come to recognize a truth which, in somewhat distorted form, found expression in the old catastrophism. We have come to recognize that comparatively short periods of rapid geographical change alternate with long periods of relative stability or slowly progressive change. This is, in substance, the doctrine of critical periods as formulated by Le Conte. It is precisely in those critical periods that the record fails, and the gap is indicated by unconformability. Darwinians and Lamarckians alike must recognize that the periods of rapid geographical change must be the periods of most rapid change in fauna and flora. Evolutionary change must be directly or indirectly the result of a failure of adjustment between organism and environment.

The doctrine of critical periods has taken somewhat more definite form in Chamberlin's discussion of the effects of intermittent subsidence of the ocean bottom. The critical periods in geological history are the times when the rigidity of the crust yields to accumulating strain, when the ocean bottom subsides, when the continents emerge to larger area and higher altitude, when more or less of mountain-making takes place, and when the geographical changes bring in their train the diminution of the atmospheric supply of carbon dioxide and a tendency to cold and arid climates. Then come the long periods in which the continents are slowly denuded, the continental shelves are extended landward by encroachment of the sea, and seaward by sedimentation, the quota of carbon dioxide is slowly replenished, and the fauna and flora which had been impoverished gradually expand to their former luxuriance. The chapters which are lost from the record are precisely the chapters which would contain the story of those critical periods, marked by extinction of manifold species, and by rapid change in adjustment to new and more rigorous conditions. The geological record of the progress of life is like a history of the United States, in which, among other less important chapters, the chapters on the Revolution and the Civil War are lost.

* Abstract of a paper read by William North Rice before the American Association for the Advancement of Science.

PROGRESS OF THE NEW INCANDESCENT LAMPS.

WE are glad to know that there seems to be a prospect that the tungsten lamp will soon be in commercial use on this side of the water. The announcement of a series street incandescent of this type is a most hopeful sign. The ordinary carbon lamp for this service has never been greatly loved by the central station man. It has not been highly efficient and its candle-power is fugitive and uncertain. If the tungsten lamp stands up well under street conditions it will prove a most valuable addition to the available material of street lighting. The filament of a series incandescent is necessarily rather stout and the tenuity of section which has been urged as an objection to the tungsten and other metallic filament lamps for ordinary incandescent circuits is obviated in applying the metallic filament to series work. It is not necessary in such work to push the filament to the highest efficiency, since it has to compete only with rather inefficient illuminants. So far as general use on incandescent circuits is concerned, the tungsten lamps have as yet made very little impression in this country, and thus far they are scarcely obtainable commercially, unless one imports foreign lamps at a somewhat excessive price. Meanwhile the tantalum lamp has come into considerable use where it has been commercially attainable. It has not to any material extent cut into the production of carbon filament lamps, but it has taken a very useful place. The tantalum lamps available in this country are claimed to have a life, on direct current, of seven to eight hundred hours, but the American manufacturer has not yet, so to speak, got the knack of the technique of manufacture so as to produce quite the degree of uniformity reached in some of the foreign tantalum lamps. There is considerable doubt as to whether the tantalum commercially obtainable for lamp filaments is of a proper degree of purity. It acts in many respects as though it were not pure, which renders uniformity more difficult of attainment. It is satisfactory to note that small tantalum battery lamps are now on the market. For this use tantalum is particularly convenient, giving a very good little lamp capable of being run easily on one or two cells of battery.

Of the new filaments, the graphitized carbon filament is the only one that has forced its way into much use. It is certainly replacing ordinary carbon at a rate that keeps the manufacturer on the jump. It is possible that the graphitized filaments are cus-

tomarily rated at a specific consumption rather less than will ultimately prove desirable in attaining the most useful length of life, but they are certainly a very material improvement that is being fully appreciated. Meanwhile it is about time that we heard something more from the Helion lamp. Aside from its interesting chemical features this illuminant is the only one of the new incandescents which possesses a filament comparable in size with the ordinary carbon filament and possessing a considerable degree of mechanical strength; it therefore gives promise of lamps for use on ordinary incandescent service in small candle-powers. A 20-watt, 16-candle-power lamp will appeal powerfully to users, and unless some movement is soon set on foot to increase the normal unit to 25 candle-power or larger, the central stations may look for trouble in the future.—Electrical World.

ELECTRICAL NOTES.

The German government has erected a wireless telegraphy station on the top of a hill 328 feet high at Tsingtau, China. The station, which has a practical range of about 100 nautical miles, is the property of the Kiaochow government, and is used to communicate with men-of-war of the German navy, but will be thrown open for general public use before long on conditions which have not as yet been determined.

An ingenious use for wireless telegraphy is projected in Berkeley, Cal. A pole has been erected on the site of the new town hall, and experiments are being made to test the feasibility of summoning policemen from their beats in the event of any emergency call. The receiving station will be placed in the helmets of the men. When a message is sent out, a bell is rung in the patrolman's pocket, and the message itself recorded in the form of dots and dashes.

Preparation of an Inexpensive Electric Battery.—First process: Mix in equal parts crushed manganese peroxide of the size of a pea, with coke or retort coal, also broken in small pieces. Inclose the whole in a canvas sack and place a piece of retort coal in the middle. Tie the sack at the upper part and put it in a vessel containing a solution of chlorhydrate of ammonia and a piece of zinc. Second process: Take a porous vessel of about 6 inches diameter, and heap around a piece of retort coal, coke in small pieces mixed with a little chloride of lime. Add some melted pitch to counteract the odor of the chlorine. Put into an outer vessel: salt water (1 part by weight of kitchen salt to 4 parts of water), and a piece of zinc. A little salt water, four times a year, will keep up the strength of the battery.

One of the difficulties preventing the wider uses of wireless telegraphy has been the absorbing power of daylight. An impulse which between the hours of 10 and 12 at night will produce an effect equivalent to 1,200, will at noon give a strength of signal of only 30. Prof. R. A. Fessenden states in the London Electrician that he has developed a new method of sending wireless messages, which cuts down this daylight absorption to a small fraction of its previous amount. The system has been tested between Brant Rock, Mass., and the West Indies, a distance about the same as that between Ireland and Newfoundland. The new impulses are less efficient than the old ones. Where the old impulse produces an effect of 1,200 at night, the new impulse under the same conditions will produce an effect at the receiving station of only 80. But at the noon hour its effect is 76. Prof. Fessenden considers that the weakness of his signals is not of consequence, compared with the advantage of the practical uniformity of day and night transmissions. He believes that transatlantic wireless messages, during daylight, are assured.

An interesting comparison has recently been given by Dalémont in the Revue Electrique between the selling price, the cost of material, and the cost of labor for electric motors in 1904 and in 1900. The following table gives the approximate average cost for motors of 1 horse-power to 50 horse-power in 1904 stated as a percentage of the cost in 1900:

Direct-current.

	German makers. Per cent.	French makers. Per cent.
Selling price	63.2	59.8
Material	73.5	[illegible].3
Labor	65.3	55.7

Three-phase.

	German makers. Per cent.	French makers. Per cent.
Selling price	64	67.8
Material	64.3	69.4
Labor	53.5	61

It will be seen that, in spite of the increasing cost of iron and copper, the cost of material fell decidedly, due probably to the improved design as regards ventilation, etc. The lower cost of labor may be accounted for by the replacement of manual labor by machine tools.

Commissioner John H. O'Brien, of the Electricity Department of New York city, has advised the New York Central Railroad officials that the company must at once put its high-power tension electric wires between 96th Street and Spuyten Duyvil underground. The distance affected is about eight miles, and the expense will be heavy, one expert placing it as high as $2,000,000. The commissioner fears that at some points where the wires of other systems cross the railroads, an accident may occur at any time. The company considered that precautions have been taken to prevent the possibility of any disaster, and contend that it is impracticable to do what the commissioner demands. The wires in dispute were only recently erected. According to a representative of the railroad company, after the plans had been adopted they were submitted in August, 1905, to the Commissioner of Water Supply, Gas, and Electricity. No action was taken until March, 1906, when they were approved except as to the aerial wires. In the meantime the company had proceeded with the construction of the wires, as it was bound to do, unless the operation by electricity was to be delayed.

ENGINEERING NOTES.

Consul-General H. B. Miller, of Yokohama, reports that the Japanese government decided at a recent cabinet meeting to improve arrangements on various lines after the nationalization of railways is effected. The following enterprises are expected to be carried out for the five consecutive years from next fiscal year or before the opening of the great exposition of Japan, 1912, with about $75,000,000: Doubling lines (830 miles), $41,500,000; constructing 900 locomotives, $11,250,000; constructing 19,000 vans, $9,500,000; constructing 1,000 passenger cars, $5,000,000; extending and reconstructing stations, $7,500,000, and building five steamers, $750,000.

The 30-foot ship channel under construction from Philadelphia to the sea, on which exceptional progress was made during the year ending June 30, 1907, is expected to reach completion some time next year. Major J. C. Sanford, Corps of Engineers, U. S. A., who has had the supervision of the work, on July 10 sent a report to the War Department at Washington for the fiscal year ending June 30, showing the immense amount of improvement work done. Up to June 30, 1907, the sum of $4,936,550 was spent in the work of dredging and of constructing bulkheads for the reception of dredged material and to act as training walls to direct the currents. Over 35,000 feet of bulkhead have been built, and 30-foot channel aggregating 76,000 feet in length has been dredged. The greatest draft of water that could be carried at mean low-water on June 30, 1907, over the shoalest part of the river, below Philadelphia, was about 23 feet. The dredging of this part of the channel to 30 feet has recently been begun. It is proposed to apply the available funds to completion of the project and maintenance of the already dredged channel. This will include widening of the channel beyond 600 feet at the bend below Philadelphia, as well as dredging and rock removal in other sections.—Engineering News.

The Turkish government has in hand a scheme whereby the land lying along the valley of the Euphrates can be restored for cultivation. For some years past the river has been changing its course; some years ago it eroded the bed of the Hindiya canal, which became merged into the river, and then the Euphrates gradually left its old bed for that of the canal. The original course thus became dried up for a considerable time of the year, and is now so rapidly silting up that less water is available each year for irrigating the land through which it passes, with the result that these areas are now being abandoned. The Turkish government has requisitioned the services of a French engineer, who has formulated plans for the erection of a barrage across the old Hindiya canal, which will occupy three years in construction. The intention of the government is to reclaim for agriculture the whole of the land of Mesopotamia between the Tigris and Euphrates, and already some of the ancient canals built by Assyrians in the vicinity of the ruins of Babylon have been cleaned out and restored to their original condition and service. Though these efforts have been hitherto carried out upon a limited scale, the results have exceeded expectations, since the reclaimed land is unusually fertile, and lends itself to extensive and remunerative development. In the time of the Assyrians the country was intersected by a network of canals, the beds of which still remain, and only require renovation to be brought into service. The total area available for irrigation from the ancient canals is approximately 40,000 square miles, and the work that is now in progress has long been advocated by European engineers, whose suggestions have, however, not hitherto been acted upon. But as the work so far carried out has shown a distinct benefit to the imperial revenues, it is now to be pushed forward with greater enterprise.

TRADE NOTES AND FORMULÆ.

To Remove a Broken Screw from a Watch Plate.—When there is a broken screw in a plate, not projecting in either side, the best way to move it without damaging the plate is to put it on the lathe between two points slightly blunt; apply strong pressure on one of the points to keep the screw steady, and turn the plate. Nine times out of ten the attempt will be successful.

To Clean Copper Thoroughly.—Some copper articles are difficult to clean with powders on account of their ornamented surface. This difficulty is obviated by means of acids, which restore the luster. Should the object be greasy, it should be cleaned by dipping in a hot solution of soda, then rinsed in clear water. A bath for imparting brilliancy is prepared as follows: Nitric acid, two parts; sal ammoniac, one part; or, sulphuric acid, one part; nitric acid, one part; water, one part. The sal ammoniac must be dissolved in water to saturation. The articles should not be immersed more than two or three seconds. They are rinsed first in cold water, then in soapy hot water and dried in warm sawdust.

A paste which will clean polished or varnished surfaces of wood or marble without damage as well as brass or other metals, is composed as follows: A cereal flour or wood pulp, 40 parts; hydrochloric acid, 45 parts; chloride of lime, 16 parts; turpentine, ½ part. The ingredients are mixed thoroughly to a paste. If wood-work is to be treated, it is covered with the paste and left for a time. The paste is then removed by rubbing quickly with a piece of soft leather or a brush, which removes all dust and grease, leaving a surface perfectly clean. By means of a little friction with a cloth or pliable leather, a polished surface is produced on wood, and a luster imparted to objects of metal. The addition of chloride of lime tends to keep the paste moist for a considerable time, whatever the temperature, thus permitting the removal of the paste without damaging the polish or varnish, while the turpentine removes all disagreeable odors during the employment of the compound.

Recent Gilding Processes.—

A new process of gilding or silvering metal is described by Sig. Bacciochi, of Italy. The metal should be slightly roughened, and after it is thoroughly cleaned a caustic with a base of liquid silver is deposited. It is dried and a coating of silver applied; this is covered with potassium cyanide. The article plated is then wrapped in hemp canvas and heated to 300 deg. C. When the wrapping is burnt the article, still hot, is passed to the polishing room.

The metal known in Europe as "chemical gold" is a compound of copper, zinc oxide, crystallized nitrate of baryta, zinc nitrate, zinc sulphophenate, and minium.

An Electrolyte for Electro-gilding.—A soluble gold and a soluble silver salt are dissolved in a solution of potassium cyanide. To this is added a soluble earthy alkaline salt, such as calcium, barium, magnesium or strontium; or an earthy salt such as aluminium or glucinium previously neutralized by a caustic alkali or an alkaline cyanide. Finally the bath receives a proportion of nitric acid, determined according to its concentration and the conditions of electrolysis.

Dr. Göttig, of Berlin, has introduced a method of gilding metals by spontaneous reduction. Gold chloride in aqueous solution is decomposed by sodium sulphide or sodium sulphocyanide. To the liquid is added alcohol or oxalic acid. With sodium or arsenic pentasulphide reddish deposits are obtained.

Plating on Aluminium.—By the recent Hinque process the aluminium surface is first coated with silver, by rubbing it with a powder consisting of cream of tartar 10 parts, silver nitrate 10 parts, and sodium chloride 150 parts, by weight. A very thin gold or silver leaf is then applied, and the aluminium plate is put in an annealing oven, and heated to a temperature of from 250 deg. to 300 deg. C. (482 deg. to 572 deg. F.) Afterward it is subjected to the action of rollers to fasten the leaf.

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